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MAR 1 1923

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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.2.

VOL. CXV.—No. 2983.] *LONDON: FRIDAY, MARCH 2, 1923.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See's Ash Ejector.
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Great saving of labour. No noise. No dust. No dirt. Ashes discharged 20 ft. clear of vessel.—Apply, F. J. TREWENT & PROCTOR, LTD., Naval Architects and Surveyors, 43, Billiter Bldgs., Billiter St., London, E.C. Od 4835

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See Advertisement page 67.

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See Advertisement Page 94. 1111

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See half-page Advertisement, page 66, Feb. 16.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.
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TENDERS.

CONTRACTS AND TENDERS.

BOMBAY PORT TRUST.

THE CONSULTING ENGINEERS AND AGENTS are prepared to receive

Tenders for:—

(1) Fifty OPEN GOODS WAGONS (Four Wheeled), complete without wheels and axles.
(2) 100 PAIRS of WHEELS AND AXLES.

Specifications and Forms of Tender can be obtained at Dartmouth House, 2, Queen Anne's Gate, Westminster, London, S.W.1, on or after 5th March, 1923. A fee of £1 1s. will be charged for the Specification, but will be returned on receipt of a *bona fide* Tender.

Tenders must be submitted not later than Noon on Friday, 23rd March, 1923.

The Trustees do not bind themselves to accept the lowest or any Tender. X 772

SOUTH STAFFORDSHIRE WATERWORKS COMPANY.

PRESTWOOD BOREHOLES.

CONTRACT No. 1. TO BOREHOLE SINKERS.

The Chairman and Directors are prepared to receive

Tenders for Sinking Large

BOREHOLES on the site of the Prestwood Pumping Station at Stourton, near Stourbridge, in the County of Stafford.

Copies of Conditions of Contract, Specification with Form of Tender and Schedule of Quantities, may be obtained from the undersigned.

Sealed Tenders, addressed to me and endorsed "Tenders for Boreholes," must be delivered not later than Noon, Thursday the 15th March.

The Chairman and Directors do not bind themselves to accept the lowest or any Tender.

FRED. J. DIXON, M.Inst.C.E., Engineer.

Engineer's Office,
26a, Paradise Street,
Birmingham.
February, 1923. X 685

URBAN DISTRICT COUNCIL OF WINDLESHAM (SURREY).

NEW SEWERAGE AND SEWAGE DISPOSAL SCHEME FOR BAGSHOT, LIGHTWATER AND WINDLESHAM.

UNEMPLOYMENT RELIEF WORKS. GENERAL CONTRACT.

The Urban District Council of Windlesham invite

Tenders from Responsible and

Experienced Contractors for the CONSTRUCTION of these WORKS, which comprise about 10 miles of Stoneware and Cast-Iron Sewers, Brick, Concrete and Cast-Iron Manholes, Flushing Tanks, Ventilating Shafts and Columns, Cast-Iron Rising Mains, Air Mains, Engines, Compressors, Ejectors, Ejector Stations, Engine Houses, Balancing, Detritus, Sedimentation, Upward Flow, Storm, Humus and other Tanks, Percolating Filters, Laying Out Storm Water Area, Roads, Paths, and other Incidental works.

A copy of the Specification and Form of Tender may be obtained on application, in writing, to MAJOR T. J. MOSS-FLOWER, Civil Engineer, 28, Victoria Street, Westminster, S.W., and Carlton Chambers, Bristol, at his Bristol Office, on and after 5th March, 1923, on deposit of a £10 Bank of England Note, which will be refunded provided a *bona fide* Tender be received, and is not withdrawn before the sealing by the Council of one of the Tenders, and provided also that all documents supplied be returned to the Engineer. On production of a receipt for the deposit, persons tendering may inspect the plans at Bagshot on a day and at a time and place which will be communicated to them.

The Contractor carrying out the work will be required to comply with the regulations of the Unemployment Grants Committee with regard to the employment of labour during the performance of the Contract.

Sealed Tenders, endorsed "Tender for Bagshot, Lightwater and Windlesham Sewerage and Sewage Disposal Works, General Contract," are to be delivered at the Council Offices not later than Noon on 20th March, 1923.

The lowest or any Tender will not necessarily be accepted.

Dated this 24th day of February, 1923.

(By Order),
EDWYN T. CLOSE,
Solicitor and Clerk to the Council.

Council Offices,
Bagshot (Surrey). X 731

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Friday, 23rd March,

Tenders for the Supply of:—

1. LOCOMOTIVE ENGINES and TENDERS.
2. SUPERSTRUCTURE for renewal of Bassein Bridges.

Tenders must be made on forms, copies of which, with specification, can be obtained at these Offices on payment of 20s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France,
Westminster, S.W.1.
28th February, 1923. X 769

BOMBAY, BARODA & CENTRAL INDIA RAILWAY COMPANY.

The Directors are prepared to receive up to Noon on Wednesday, 14th March,

Tenders for the Supply of

CHEMICALLY DRESSED WAGON COVERS.

Tenders must be made on forms, copies of which, with Specification, can be obtained at these offices on payment of 10s. each (which will not be returned). The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France,
Westminster, S.W.1.
28th February, 1923. X 730

CORPORATION OF CALCUTTA.

NOTICE TO CONTRACTORS.

Tenders are Invited for the

SUPPLY, ERECTION and INSTALLATION of an AERIAL ROPEWAY for the removal of the City Refuse from the site of the motor lorry platform at Chingrighatta to the Square Mile.

Tenders should be submitted in duplicate and should be enclosed in a sealed cover superscribed "Tender for the Erection and Installation of an Aerial Ropeway," and should be addressed to the Deputy Chairman, Corporation of Calcutta, Central Municipal Office, 5, Corporation Street, Calcutta, and must reach him on or before the 30th April, 1923, when they will be opened in the presence of such tenderers or their accredited representatives as may be present.

Tenders must remain open for acceptance for at least three months from the date of opening.

For further particulars, if required, apply to the Chief Engineer, Corporation of Calcutta.

One set of the specification in duplicate with copies of plans may be obtained gratis from Messrs. The Indian and Eastern Engineer, 50, Fenchurch Street, London, E.C. 3.

The Corporation do not bind themselves to accept the lowest or any Tender.

JAMES R. COATS, B.Sc., M.Inst.C.E., Chief Engineer.

Central Municipal Office,
31st January, 1923. X 664

STATE ELECTRICITY COMMISSION OF VICTORIA.

TENDERS FOR PLANT.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form, Specification, Contract Conditions and Drawings may be obtained or inspected at the office of

THE AGENT-GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C. 2.

SPECIFICATION No. 23/28.
WATER SCREENING PLANT.

Prospective tenderers without Australian Representation should note that time does not permit of their detailed Tender being received at this Office by date of closing of Tenders, and should therefore cable direct, the following particulars:—

1. Price.
2. Delivery.
3. Particulars marked with an asterisk in the Schedule of Plant details.
4. Whether or not one set may be delivered before the complete plant, and if so at what date.

Detailed Tender on prescribed form should be posted by earliest possible mail.

The Commission does not bind itself to accept the lowest or any Tender.

R. LIDDELOW,
Secretary.

State Electricity Commission of Victoria,
Melbourne, Australia. X 726

THE GREAT INDIAN PENINSULA RAILWAY COMPANY.

The Directors are prepared to receive

Tenders for the Supply of

the following STORES, namely:—

	Fee for Specification.
No. 1.—Stationery, &c.	10s.
No. 2.—Spare Parts of Carriages and Wagons (W.I. Axle-guards, &c.)	£1.
No. 3.—Helical Springs and Volute Springs	£1.
No. 4.—Spare Parts of Carriages and Wagons (Buffers, &c.)	£1.
No. 5.—Light Steel Trolley Wheels and Axles	7s. 6d.

Specifications and Forms of Tender may be obtained at this office on payment of the fee for the Specification, which payment will not be returned.

The fee should accompany any application by post. Cheques and Postal Orders should be crossed and made payable to the Great Indian Peninsula Railway Company.

Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Stationery, &c." or, as the case may be, not later than Eleven o'clock a.m., on Tuesday, the 13th March, 1923.

The Directors do not bind themselves to accept the lowest or any Tender.

R. H. WALPOLE,
Secretary.

Company's Offices,
48, Copthall Avenue, E.C. 2.
London, 28th February, 1923. X 761

APPOINTMENTS OPEN.

Wanted, Metallurgist for

large Manufacturing Plant in Scotland; must have had experience in research work and acquainted with modern methods of heat treatment of steel. State qualifications and last employer. Replies will be treated confidentially.—Address, METAL, WM. PORTEOUS & Co., Advertising Agents, Glasgow. X 673

Assistant to the General

Manager REQUIRED by a large Iron, Steel and Coal Company. Applications must be from gentlemen of about 30 years of age, and give details of training, scientific and technical qualifications and particulars of positions already held. The appointment carries a liberal salary and prospects of advancement.—Address, X 752, Offices of ENGINEERING.

Superintendent Required for

Engine Department of large Engineering Works in Midlands; experience in economical production of Crude Oil Engines of the Semi-Diesel and Cold Starting Types essential. State age, experience and salary required.—Address, X 718, Offices of ENGINEERING.

COUNTY OF LONDON.

The London County Council invites

Applications for the Position

of SUPERINTENDENT of Blackwall, Greenwich and Rotherhithe Tunnels and Deptford Creek Bridge, at a salary commencing at £300 a year and rising by annual increments of £12 10s. to a maximum of £350 a year.

The foregoing salary is based on pre-war conditions and is at present subject to temporary additions on the Civil Service Scale, fluctuating according to the cost of living and making the total commencing remuneration, at present, about £441 a year. In addition, the Superintendent will be provided with house, light and coal (valued for superannuation purposes at £30 a year) free.

Candidates must not be less than 30, nor more than 45 years of age on the latest date for receiving applications, and must have been trained as mechanical engineers or electricians, and have a working knowledge of both trades.

Applications must be on the appropriate official form, which gives particulars of the duties and specifies the conditions on which the appointment will be held.

Forms may be obtained from the Clerk of the Council, The County Hall, Westminster Bridge, S.E. 1, and must be returned to the County Hall not later than Four p.m. on Monday, 12th March, 1923. Applications for forms must be accompanied by a stamped addressed foolscap envelope.

Preference will be given to men who have served or attempted to serve with H.M. armed forces. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.

Assistant Engineers

REQUIRED for the Public Works Department of the Federated Malay States for four years' service with prospect of permanency. Salary $400 a month rising to $600 a month by annual increments of $25 a month plus a temporary non-pensionable allowance of 10 per cent. The exchange value of the Dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is at present considerably less than that of 2s. 4d. in the United Kingdom. Free passage provided. Candidates, age 25 to 35, unmarried, must have received a good theoretical training, preferably at a University or Engineering College recognised by the Institution of Civil Engineers, or have completed articles with Civil Engineer of good standing, and have passed the examination for Associate Membership of the Institution of Civil Engineers. Possession of an Engineering or Science Degree preferred. Must have had at least two years practical experience in the design and execution of works of some considerable magnitude. A knowledge of modern road making and maintenance is desirable.—Apply at once by letter giving brief details of qualifications and experience to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, London, S.W. 1, quoting M/11839. X 720

INDIAN SERVICE OF ENGINEERS.

THE SECRETARY OF STATE FOR INDIA IN COUNCIL will in 1923

Appoint 11 Assistant

EXECUTIVE ENGINEERS for this Service if so many suitable candidates present themselves.

Every candidate must be a British Subject, or a ruler or subject of any State in India in respect of whom the Governor-General of India in Council has made a declaration that he is to be considered eligible.

European candidates who were of military age prior to November, 1918, must have served in His Majesty's Forces during the War, or have been prevented on adequate grounds from so serving. European candidates must have been born on or after 2nd August, 1898, and on or before 1st August, 1901.

Indian candidates must have attained the age of 21 and not attained the age of 24 years on 1st July, 1923, except that in the case of an Indian who has rendered service of the nature defined in the preceding paragraph, the same maximum age limit as for Europeans will apply.

Every candidate must either (1) have obtained one of certain recognised University degrees or other distinctions in Engineering, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers, or been exempted by the Institution from such examination, or (3) produce the required evidence that he is otherwise eligible under the Regulations.

Applications from candidates must reach the India Office not later than 1st April. Printed forms, together with information regarding the conditions of appointment, may now be obtained from the SECRETARY, Public Works Department, India Office, Whitehall, London, S.W. 1.

India Office, London.
11th December, 1922. X 207

Experienced Sales Engineer

for Electrical Hoisting Machinery, Lifting Magnets, etc. Give fullest particulars. Required to commence duties at once. Works situated in the Midlands.—Address, X 735, Offices of ENGINEERING.

Engineer.—Wanted, Fully

Qualified YOUNG ENGINEER (preferably degree) to follow up enquiries and seek new business for Foundry and Engineering Works. Full time only. State salary required.—Address, X 680, Offices of ENGINEERING.

A Large Manufacturing Firm

in England REQUIRES the ASSISTANCE of an ENGINEER with general experience in the design, construction, and the practical operation in service, of electric locomotives.—Address, stating experience and salary required, X 733, Offices of ENGINEERING.

Wanted.—Engineer for Saw

Mill in Burmah, accustomed to Electric Motors and High Speed Engines. Must do own repairs. Married man preferred, age 28 to 35. Furnished House provided. Four years' agreement. Salary starting Rupees 600 per month and local allowances. On probation for first year. Free passage out.—Apply, giving experience and copies of testimonials, to BURMAH, WM. PORTEOUS & Co., Glasgow. X 722

Good Mechanical Engineering

DRAUGHTSMAN REQUIRED, with centrifugal pump design experience preferred, for Midland Firm. State age, wage and experience.—Address, X 743, Offices of ENGINEERING.

Draughtsman Wanted, with

experience in Steam Turbine work, preferably of the Impulse Type.—Apply, stating experience in detail, age, whether married or single; wages required, and when at liberty, to W. H. ALLEN SONS AND CO., LTD., Bedford. X 749

Draughtsman Required for

Works in Midlands, used to Gasholders and Gas Works Plants. State age, salary and full particulars of experience.—Address, X 750, Offices of ENGINEERING.

Draughtsman Required, Age

about 23. One used to designing Grabs. State salary and experience—Address, X 716, Offices of ENGINEERING.

Draughtsman Required, well

experienced Ferro-Concrete Structural Design; part or possibly whole time.—Address, stating wages, X 729, Offices of ENGINEERING.

Draughtsman Wanted, ex-

perience in design Crushing and Cement Machinery.—Write, giving full particulars, experience, age and salary required, to W. J. C., ENGINEERING DEPARTMENT, EDGAR ALLEN & Co., LTD., Imperial Steel Works, Sheffield. X 725

Experienced Draughtsman

REQUIRED with knowledge of design of steam navvies and diggers. Advertisers are well-known Engineers in Yorkshire. Give full particulars of experience, age and salary.—Address, X 744, Offices of ENGINEERING.

Draughtsman Wanted, Fully

experienced in Railway Carriage and Wagon Work. Experience in Steel Coach Design an advantage.—Apply, by letter only, stating age, experience, and salary required, to CHIEF DRAUGHTSMAN, LEEDS FORGE CO., LTD., Carriage Works, Newlay, Leeds. X 717

Draughtsmen Wanted;

thoroughly experienced in the design of:—
(a) Heavy steel bridges, both fixed and movable.
(b) Steel caissons and gates for dock entrances.
(c) General dock and railway construction work.

Only men of the highest abilities in design and detailing of such work need apply.

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On TUESDAY, WEDNESDAY, THURSDAY and FRIDAY, MARCH 13th, 14th, 15th and 16th, commencing each day at 11.30 a.m prompt,
Including:—

MANNHEIM OLEUM PLANT—20 UNITS EACH of Six MANNHEIM LUMP BURNERS and Four UNITS of One HERRESCHOFF FURNACE and Two MANNHEIM LUMP BURNERS, all with firing chambers, forewarmers and superheaters. 40 M.S. GAS COOLERS. 20 M.S. HEAT EXCHANGERS. 50 M.S. ABSORPTION TOWERS, 5 ft. 11 in. dia., by 24 ft. high. 30 M.S. TANKS, 6 ft. by 2 ft. 11 in. deep. 30 DITTO with jackets. 100 M.S. FILTERS, 11 ft. 6 in. by 6 ft. 7 in. by 4 ft. 1 in. Five KYNOCH AIR DRYING PLANTS, each with fan, and Two LEAD SCRUBBER TOWERS, CENTRIFUGAL PUMPS, EXHAUST FANS, etc.

T.N.T. PLANT—Five UNITS OF T.N.T. NITRATION AND WASHING PLANT, with 50 C.I. NITRATION POTS, 6 ft. 7 in. dia. by 6 ft. deep, with LEAD COILS AND STIRRING GEAR. 10 C.I. SEPARATOR PANS, 6 ft. 6 in. dia. 24 C.I. CRYSTALLISER PANS, 6 ft. by 7 ft. 10 in. dia., with STIRRING GEAR. 153 SETS OF GRANULORS with G.M. ROLLS, 2 ft. by 3 ft. 2 in. dia.

TETRYL PLANT—C.I. RETORTS, NITRATING POTS, LEAD COOLERS, C.I. STILLS, COPPER ACETONE STILL, etc.

BOILER HOUSE PLANT—21 LANCASHIRE BOILERS, 30 ft. by 8 ft., 160 lbs. 10 COAL ELEVATORS. Two M.S. CHIMNEYS, 100 ft. high. Two DITTO, 90 ft. high.

TANKS—40 LEAD AND LEAD LINED TANKS, from 20 ft. by 12 ft. by 7 ft. to 4 ft. dia. by 3 ft. deep. 27 M.S. TANKS, 9 ft. dia. by 30 ft. long. 24 DITTO, 20 ft. dia. by 12 ft. deep, and about 100 M.S. and C.I. Tanks of smaller sizes.

GENERAL PLANT—Seven AIR COMPRESSORS from 270 to 750 c. ft. capacity, 85 to 110 lbs. pressure. 12 ROOT'S HIGH PRESSURE BLOWERS, 4000 c. ft. per min. 10 STEAM-DRIVEN VACUUM PUMPS, 12 in. by 18 in. by 18 in. One DITTO, 12 in. by 15 in. by 12 in. BLAKE CRUSHER, 20 in. by 10 in. CRUSHING ROLLS, 30 in. by 12 in. Two UNDER DRIVEN MORTAR MILLS. ROTARY RABBLE GRANULATOR, 10 ft. pan. 12 ELECTRIC GOODS LIFTS, from 4 tons to 10 cwt. capacity. Two HYDRAULIC DITTO, 15 and 20 cwt. capacity. OVERHEAD TRAVELLING CRANES AND RUNWAYS. 17 WEIGHBRIDGES, 6 to 22½ tons. WEIGHING MACHINES, 10 cwt. to 2 tons. FILTER PRESSES, COTTON WILLOWING MACHINES, PNEUMATIC PRESSES, 11 WATER-DRIVEN HYDRO EXTRACTORS, IBIS CONTINUOUS DRYER. LIGHT RAILWAY, about 1900 yards 2 ft. gauge track and 900 yards 18 in. gauge track, 30 lbs., 16 lbs., and 13 lb. Section, with points, crossings and turntables. 20 M.S. DOUBLE SIDE TIP WAGONS, 18 in. gauge. An immense quantity of C.I. and W.I. STEAM, WATER and AIR PIPING, from 14 in. dia. down. Several miles of HEAVY LEAD PIPING. About 300 TONS OF STRUCTURAL STEEL JOISTS and ANGLES. A large quantity of Timber, Beams, Planks, and Scantlings.

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For Sale, &c., continued on page 95.

FLOW OF WATER THROUGH SPIRAL RIVETED STEEL PIPES.

By E. PARRY, M.Inst.C.E.

IN a recent number of ENGINEERING* an article was published in which the principle of dynamic similarity was applied to co-ordinate a comprehensive series of observations upon the frictional resistance to the flow of water through pipes with concrete surfaces. The same method is herein applied to experimental observations upon the flow of water through spiral riveted steel pipes. The experiments were carried out at the Engineering Experimental Station of the Purdue University, and are recorded in Bulletin No. 8† of that establishment. The experiments were carefully conducted, and, as will be seen later, afford conclusive proof of the applicability of the basic principle mentioned to rough surfaces represented by laps and rivets. If the principle of dynamic similarity is at all applicable it is asserted that $R/\rho v^2$ should be a function of $v d/\nu$, where R is the frictional resistance in absolute units of force per unit of surface, ρ is the density of fluid, v the mean velocity of flow, d the diameter and ν the kinematic viscosity.

Stanton and Pannell‡ proved the applicability of the principle to smooth pipes without joints, whilst proof is adduced in the article printed in ENGINEERING, already cited, of its applicability to rough surfaces such as concrete pipes and conduits, provided that the joints are smooth and well made. It was also shown that in regard to large conduits the degree of roughness and irregularity may be considerable without affecting the result, which is a consequence of the theory, and constitutes an additional proof of its soundness and general applicability to practical problems. No proof has, however, existed hitherto regarding the applicability of the principle of dynamic similarity to surfaces whose roughness is of the order represented by spiral riveted pipes of the sizes experimented on. Before dealing with the tests under review it may be well to set out the equations with a view to bringing out the various coefficients in use in hydraulic practice and of establishing the relation between them. This is necessary in order to facilitate the transformation from one set of coefficients to another.

Starting with the hypothesis that the frictional resistance F of a fluid of density ρ moving with a velocity v relative to a surface with which it is in contact is proportional to the extent of surface S to the density ρ, and to the square of the relative velocity, we have

$$F = k \rho S v^2,$$

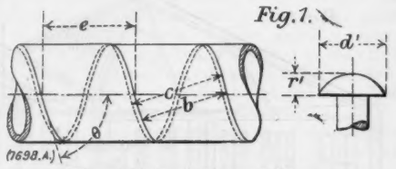
where k is a coefficient originally assumed to be constant and later discovered not to be a constant, since when various attempts have been made to give it mathematical expression, notably by D'Aubusson, Prony, Eytelweis, Weisback, Bazin and Kutter. The theory of dynamic similarity hypothecates that k is a function of $v d/\nu$ as previously explained, and for practical purposes the form of the function is quite immaterial; all that is required is to plot the values of k in terms of $v d/\nu$. We have therefore in absolute units:

$$\frac{F}{\rho v^2 S} = \frac{R}{\rho v^2} = k = \phi\left(\frac{v d}{\nu}\right)$$

If $p_1 - p_2$ be the difference of pressure at the two ends of a pipe of length l in gravitational units we have:

$$p_1 - p_2 = \frac{k \rho l v^2}{\frac{d}{4} \cdot g} = k \rho \frac{l}{r} \frac{v^2}{g}$$

Fig. 1.



Characteristics of Pipe and Rivets.

Diameter. Nominal In.	Diameter. True In.	θ Degrees and Minutes.	b* In.	c* In.	e In.	d' In.	r' In.	Number of Rivets per Revolution.
4	4·13	53—12	7·7	9·0	9·2	0·25	0·10	19
6	6.01	57—15	10·3	12·1	12.1	0·30	0·10	29
8	8.12	66—51	10·05	11·8	10·9	0.30	0·10	30
10	10·21	70—58	10.6	12·0	11·3	0·35	0·10	34

* Measurement on a curved surface.

If $p_1 - p_2 = \rho h$, and

$$h = k \cdot \frac{l}{r} \cdot \frac{v^2}{g} = \frac{1}{C^2} \frac{l}{r} v^2 = f \frac{l}{r} \cdot \frac{v^2}{2g}$$

where C is Chezy's coefficient, and f is Darcy's coefficient. The relation between the coefficients stands, therefore, as follows:—

$$\frac{k}{g} = \frac{1}{C^2} = \frac{f}{2g}$$

Representing h/l by s we have the following equations:

$$\frac{R}{\rho v^2} = \frac{r s g}{v^2} = k = \frac{g}{C^2} = \frac{f}{2} = \phi_1\left(\frac{v d}{\nu}\right)$$

also

$$\frac{r s}{v^2} = \frac{k}{g} = \frac{1}{C^2} = \frac{f}{2g} = \phi_2\left(\frac{v d}{\nu}\right)$$

where ϕ stands for "function of," and where the suffices indicate different values of the function.

In Figs. 2 and 3 the values of $1/C^2$ or of $r s/v^2$ have been plotted against $\log_{10} v d/\nu$ for convenience owing to the large range involved.

Referring to the tests, the pipes experimented on were made of galvanised iron of No. 16 gauge and formed in accordance with the drawing and the specification shown in Fig. 1. It will be seen that four diameters of pipes were experimented on, viz., 4-in., 6-in., 8-in. and 10-in. The pipes were made in 20-ft. lengths and the gauge readings were taken across two lengths, leaving one joint in between, and inasmuch as this was carefully made the disturbance due to joints, which is very evident in some experiments, was in this case eliminated. In the present experiments the rate of flow varied from 1·34 ft. per second to 20 ft. per second, and the values of $v d$ between 9·8 and 0·54, where v is the mean velocity in feet per second and d the diameter in feet. The results of the tests are plotted on Figs. 2 and 3, the former with the flow with the laps and the latter with the flow against the laps. On the same sheets are plotted two curves, one being drawn through a set of observations by Stanton on smooth drawn brass pipes, and the other drawn through a set of observations by Lander on drawn steel pipes, which furnish us with two data of reference by which we are able to judge of the degree of probability to be attached to the tests upon the riveted pipes. It will be seen that, taken in mass, the tests have the same general character as in Stanton's experiments, proving that very rough pipes conform to the same law as smooth pipes, a conclusion which was also drawn from the tests upon concrete surfaces to which reference has already been made. We are further justified in concluding, on regarding the general character and trend of the observations when plotted on the chart, that there is no disturbance due to joints or to the entry of the water into, or its exit from, the section under test; this result was, of course a foregone conclusion, having regard to the nature of the arrangements made for testing and the fact that only one joint, and this carefully made, intervened between the two-gauge points.

Comparing the two sets of tests, one with and the other against the laps, it will be seen that the latter are displaced upwards as a whole, showing a higher resistance, as was to be expected. When, however, the tests are regarded in detail, some discordances are in evidence, which point to some defect in the measurements. It will be seen on referring to Fig. 2 that the resistance of the 4-in. pipe for any given value of $\log_{10} v d/\nu$ is less than the 6-in. pipe, and the latter less than the 8-in. and 10-in. pipe, whereas the reverse should be the case according to the basic theory, especially so as the ruggedness of surface is the same, *i.e.*, the thickness of plate, the size of rivet head, is the same for all sizes, as may be seen by reference to the table in Fig. 1. If we define the coefficient of roughness as the ratio of the asperities to the diameter, we have in the case of the 4-in. spiral riveted pipe a plate thickness of ¼ in. and a rivet head of one-tenth, making a total asperity of 0·1625 in. on a diameter of 4 in., *i.e.*, a coefficient of 0·0406. As regards the drawn steel pipe it is difficult to give the coefficient a definite value, but we can say that it is very much less than this, and that in consequence the position of the 4-in. pipe characteristic should be well above Lander's curve, and for reasons already stated its proper position is above the 6-in., 8-in. and 10-in. group. It is evident that some error has crept into the test on the 4-in. pipe, and it would be interesting to repeat the experiments with a view to discovering the cause of the displacement by which the position of the readings on the 4-in. and 6-in. pipes are reversed in relation to the 8-in. and 10-in. pipes.

This analysis proves the value of the method of co-ordinating observations upon fluid friction here employed; it enables one to correlate one set of experiments with another for all fluids, liquid or gaseous, under any condition of the substance, and also enables one to exercise a judgment as to the reliability of the tests and the extent to which extraneous influences have been at work. The experiments recorded in the Bulletin are of the utmost value, and afford conclusive evidence regarding the frictional resistance to the flow of fluids in spiral riveted pipes. The analysis reveals some discrepancies and irregularities, but when the

Fig. 2. FLOW WITH LAPS.

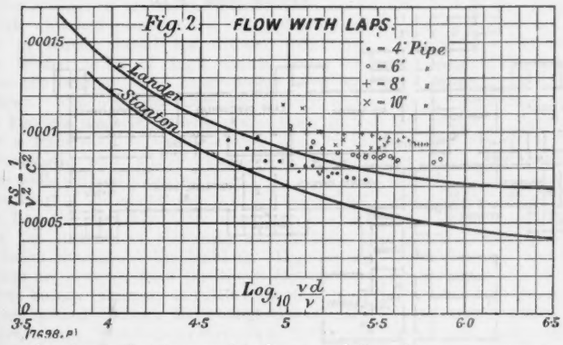
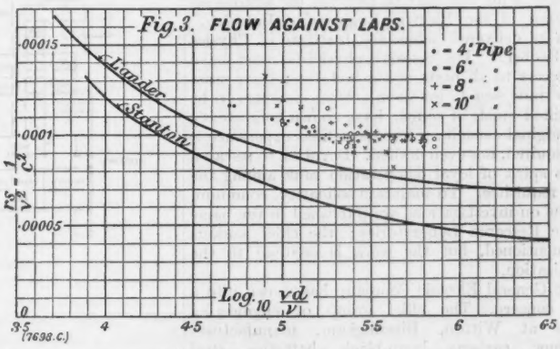


Fig. 3. FLOW AGAINST LAPS.



* "The Frictional Coefficient of Concrete Surfaces in Pipes and Channels," by E. Parry, ENGINEERING, Vol. cxiv, No. 2,958, page 285, September 8, 1922.

† "Flow of Water through Spiral Riveted Steel Pipe," by F. W. Greve and R. R. Martin, Bulletin No. 8, Purdue Engineering Experimental Station.

‡ "Similarity of Motion in Relation to the Surface Friction of Fluids," by T. E. Stanton and J. R. Pannell, Nat. Phys. Lab., Coll. Researches, Vol. xi, 1914, pages 293 to 320.

experiments are taken as a whole very definite conclusions may be reached regarding the limiting values of the resistance of spiral riveted pipes to the flow of liquids.

THE RESEARCH LABORATORIES OF THE GENERAL ELECTRIC COMPANY.

THE formal opening of the Research Laboratories of the General Electric Company, Limited, which drew a large number of visitors to Wembley last Tuesday afternoon, signified more than an addition to the number of research laboratories already established in this country. Five years ago the company decided to make research one of their objectives, fully recognising that the distinction between pure research and applied research had become meaningless. The organisers of the new laboratories were given exceptional latitude, subject to the understanding that research activities be kept independent of production activities in the sense that the factories were to retain their complete responsibility for production, whilst the research department was to be unrestricted as to the problems they wished to investigate and as to the mode of attack. The company had already development committees in their various works. Difficult problems are now referred to the Research Laboratories which Mr. C. C. Paterson, acting under Mr. H. Hirst, chairman of the company, has been organising.

An outline of the principles which guided Mr. Paterson in his task may be found in the address on "Physics in the Electric Engineering Industry," which he delivered before the Institute of Physics last October.* The research physicists must have free access to all parts of the factories; there must be no trade secrets for them. Staff members to be appointed must, of course, have shown competency and original capacity; but specialised experience is not required, nor even desired. Devotion to research and a spirit of loyal co-operation rank among the chief requisites. To maintain solidarity, communications on investigations are published in the name of the Research Laboratories; the chief workers are mentioned, but the work is credited to the organisation.

The General Electric Company has grown into a vast concern. The chief group of engineering works at Witton, Birmingham, manufactures dynamos, carbons, lamp-black, batteries, steel conduits, switchgear and insulating materials. The steam turbine and mining plant works at Erith were taken over from Messrs. Fraser and Chalmers a few years ago. Telephones are manufactured at Stoke, near Coventry; the cable works are at Southampton; instruments are supplied at Salford, railway signalling apparatus at the Union Works, Wembley. Lamp tubes are also made at the last-mentioned place, whilst the Osram Lamp Works remain at Hammersmith and the glass works at Lemington-on-Tyne. There are other well-known branch works.

The problems arising in so diverse and so widely ramified groups of factories must be so manifold that the advantages of a central research laboratory might be questioned. On the other hand, the advance of science is tending to obliterate the demarcations between physics, chemistry and engineering. Fundamentally, scientists engaged in these various branches of work are confronted by the same problems, but they attack them each in his own way. The study of sedimentation affects the hydraulic engineer and metallurgist as much as the geologist, the farmer and the painter. A new method of securing a uniform coating on wires interests the textile and ceramic industries as well; that is one of the problems which have been studied at Wembley. To deal effectively with such problems the laboratory has been converted into a factory, and in that respect the undertaking of the General Electric Company differs from other establishments in which the factory has a laboratory, but the laboratory is not itself a factory. In the laboratory-factory the process may be interrupted at any stage to investigate difficult operations and to try improvements. To do this in the factory would cause disorganisation; fundamental research must be kept out of the factory. At present laboratory-factories have been established at Wembley for making tungsten wire, lamps, thermoionic valves and primary batteries. How this is done we shall presently indicate.

The Research Laboratories are situated on the grounds on which, closer to the North Wembley station of the railway lines from Euston and from Waterloo, the Union Works of the General Electric Company have been erected, and which leave ample space for extensions of either plant. The red brick building of the laboratories has a frontage of 400 ft. and a total floor area of 80,000 sq. ft. It consists of one large block, running nearly west-east, from which two wings stretch out to the north, a west wing and a central wing; the third, the east, wing has not been built yet. Apart from the central southern extension, which forms the administration section, and the main gallery with its wings, the laboratories are essentially a one-storey building of the weaver-shed type, with north-light roof. The diagram, Fig. 1, annexed, illustrates a typical cross section through almost any part of the laboratories, while Figs. 2 and 3, also on this page, are plans of the ground floor and the upper floor respectively.

Passing through the main entrance at the south front, the visitor enters the main corridor, which forms part of a centre bay running the whole length of the building; this feature is repeated in the wings. The rooms in the bay, in Fig. 1 to the right of the corridor, serve as photographic dark rooms and store rooms and also for housing noisy machinery; they can, however, be thrown into the experimental laboratories and made available for work which requires a subdued light.

The corridor and bay strike one as low, but there is a reason for that. In the upper floor the whole width of these parts is taken up by the main gallery and the wing galleries which carry all the electric cables and the pipe trunks for water, steam and gases, for compressed air and for evacuation. The gallery floor is extended on both sides into the upper portions of the laboratories so as to provide platforms for the experimenters and for high tension apparatus and other gear which would obstruct the laboratory floor space. Glass folding doors lead from the gallery to the platforms, and the three

Fig. 1.

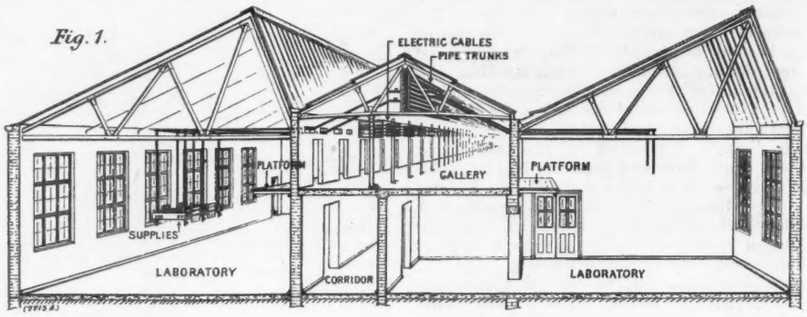


Fig. 2.
GROUND FLOOR PLAN

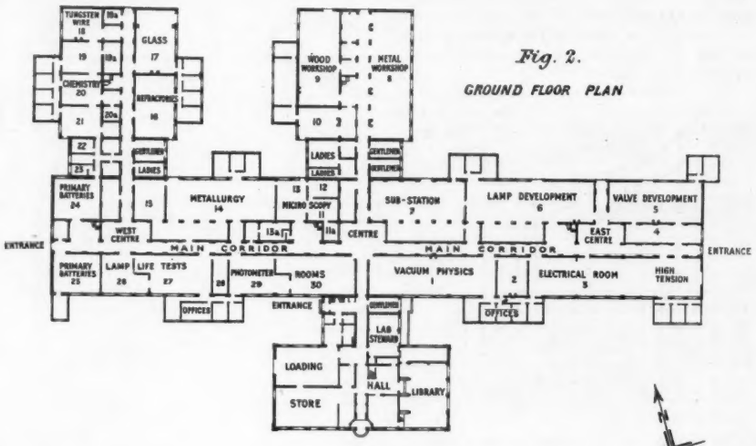
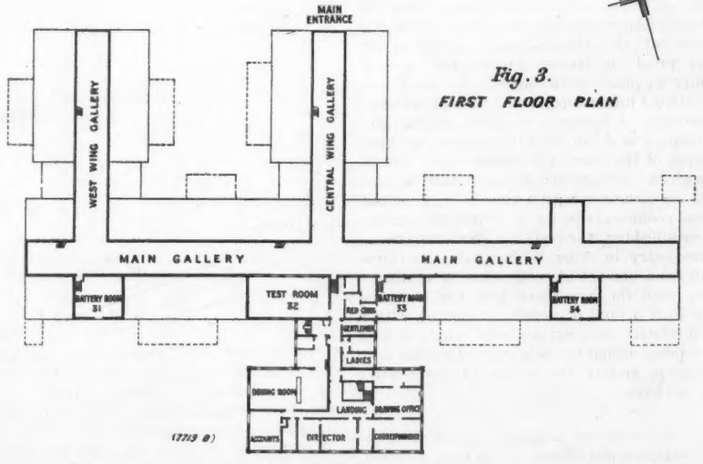


Fig. 3.
FIRST FLOOR PLAN



* See ENGINEERING, October 20, 1922, page 496.

battery rooms are also approached by steps from the gallery. The various cables and pipes enter and leave the gallery through slots in the floor and in the side walls, and the slots are provided in sufficient numbers for future needs. In order to keep the wires and pipes out of the way "cradles" are suspended from the ceilings in the rooms; the cradles bring the leads down to a height convenient for experimenters to make connections.

The gallery thus supports the arterial system of the whole laboratory, without the aid of any conduits or ducts—apart from the waste-water gulleys which run transversely across the ground floor; a remarkable flexibility is by these means secured for the electric and other services.

Some of the main laboratories are illustrated on Plates XVII to XX. Figs 4 and 5 on Plate XVII show the metal-working shop and the experimental lamp factory; Figs. 6 and 7 on Plate XVIII the vacuum physics laboratory and the experimental valve factory. Figs. 8 and 9 on Plate XIX illustrate the experimental tungsten wire factory and the lamp life-testing room. On Plate XX are two views of the central gallery, Figs. 10 and 11, showing the trunks which carry the electric cables and the pipes for water, steam and gases. Fig. 12 shows one of the three distribution switch boards placed in the lower corridor. Fig. 13 on the same plate is a view of the library, which is not the least noteworthy feature of the Research Laboratories.

The useful height of these rooms is 14 ft. The sloping ceilings of the north-lighted rooms are of smooth whitened plaster slabs, the reflecting surfaces of which spread the diffused light from open frosted units of high candle power well up in the ceilings. The other rooms have large windows. The concrete floors are covered either with jointless marbello or with granolithic; in the walls a framework of wood backing fixed to the plaster of the walls allows fixings to be attached to the walls without plugging them.

The heart of the laboratories is in the sub-station, room 7 on the plan, Fig. 2, the machinery of which keeps the currents of electricity and of gases in circulation throughout the building. High-tension currents are received from the North Metropolitan Electric Supply Company at 2,850 volts three-phase and are passed through three single-phase transformers, making high tension currents at 2,400 volts and various low-tension currents available with the aid of the main switchboard and auxiliary machinery in the sub-station. The auxiliary sources of supply comprise a motor generator, which is used for correcting the power factor, an alternating-current generator, which is electrically independent and sends its current to the lamp-testing rooms, and the boosters for the seven batteries which are installed in three rooms as already mentioned. The whole electric system is divided into two main groups, for permanent and for experimental supply. The lighting system is permanent and is not touched for experimental purposes, nor are the charging feeders and main supplies to the switchboards. The main switchboard in the sub-station is divided into panels for alternating currents and for direct currents; and since transformers, as well as the boosters and batteries, are to be tapped independently, if desirable, the design of the main switchboard required much forethought. The general distribution system may be described as a development of the arrangements which Mr. Paterson adopted in the Electrotechnics department of the National Physical Laboratory and is due to Mr. Paterson and Mr. J. H. Jolley.

There are two ring mains round the walls of every room, terminating at the plug points on the walls and on the cradles, at 110 volts A.C. and D.C. respectively. This wiring is all permanent and is not tampered with for experimental connections as far as these sockets and the cradle terminals are concerned. All the feeders and wiring up to these points are under the charge of the laboratory maintenance staff or stewards. Beyond those points the circuits are temporary and under the control of the individual investigators. The connections, so far as not made in the respective rooms, are effected on the junction switchboards, which have been installed at the three main corners of the corridor.

Fig. 12 on Plate XX illustrates, as already stated, one of these distribution corners with its two boards. The junctions at the three corners, with their total of seven boards, are not identical, but they all admit of being connected up to any of the supply sources to any laboratory. Each switch-board consists of four parts; a panel for one battery with some twenty sets of sockets for steps of 10 volts; a panel with sockets for connection to any A.C. or D.C. pressures; a panel with sockets which are the terminations of inter-connecting mains to every other similar distribution board and a panel with sockets terminating the cables which run into the special laboratory rooms which the respective panel is to serve. The fourth of these panels is underneath the other three, and it is joined to the other systems by flexible cables and plugs, which are standardised for 100 amperes and for 15 amperes. The supplies which are thus rendered available are:—415 volts three-phase; four-wire direct supply (240 volts to neutral); 110 volts D.C. machine with Tirrill regulator (attached to the main board in the sub-station); 110 volts A.C. three-phase, four-wire form transformers; 415 A.C. single-phase lamp life-test supply with Tirrill regulator; 150 volts to 0 volt to 150 volts D.C. lamp-life test supply; 0 volt to 75 volts motor booster (volts adjustable); and 110/415 volts D.C.-A.C. motor generator.

The batteries of Pritchett and Gold accumulators are stored in three rooms, opening out of the gallery, as we have mentioned already; they are situated on the southern front above rooms in which strong light would be objectionable and which are thus deprived of their sky illumination. The glass cells stand in trays which are charged with sawdust and rest on porcelain insulators; a thin film of oil floats on the top of the sulphuric acid. The oil tends to creep over the edge of the glass and down into the tray where it does no harm, but it effectually prevents the spraying of acid by the hydrogen generated; the absence of all acid fumes is indeed notable. The seven batteries installed—there is ample space for additions—vary in capacity; the total pressure available is 1,750 volts, and the aggregate capacity 1,392 ampere-hours. Most of the electric gear and fittings came, of course, from the various works of the General Electric Company.

In addition to the electric machinery the sub-station contains the vacuum and compressor plant. The two Reavel rotary compressors feed into a receiver of 250 cub. ft. capacity which is a horizontal boiler placed on the gallery; the compressors are automatically started as soon as the pressure sinks below 10 lb. per square inch. The compressed air is wanted for experiments and also for the sewage ejectors of the establishment; the drains of the building lie below the level of the sewage mains. There are further three vacuum pumps of the horizontal reciprocating type, belt-driven by 15 h.p. motors; two of these pumps are single-stage, the third is a double-stage pump, and they are kept in continuous operation throughout the day. The hot-water circulation for the radiators of the building is also controlled from the sub-station by means of a turbo-generator.

The pipe trunks—mostly steel—which are served by this and other machinery comprise the following: A 4-in. coal gas main at a pressure of 12 in. of water, provided with reducing and regulating valves for the different rooms; a 3 in. fine vacuum main for pressures ranging from 0·5 mm. to 2 mm. of mercury for backing the oil-box pumps for exhausting lamps; a 3 in. rough vacuum main, for preliminary exhaustion down to 6 mm. or 2 mm. of mercury; a 2-in. vacuum main for the same range mainly for the chemical laboratories; a 1·5 in. compressed air main, pressure 10 lb. per square inch, with regulating and reducing valves for the different rooms; a 2-in. water main, at 100 lb. per square in. Finally there is a 1-in. hydrogen main, chiefly for the tungsten laboratory, but available in other parts; the hydrogen is taken from a gas holder fed by cylinders.

Together with the electric cables these trunks are taken up into the gallery of the full length of 400 ft., in which the main trunks are carried vertically above one another up the centre of the gallery roof principals, as Figs. 10 and 11 on Plate XX illustrate. The ladders supporting the trunks form an integral part of the iron work of the principals. The electric busbars are attached to insulators fixed near the roof. The cables rest on wooden poles about 2 ft. long which are roughly threaded and are screwed through holes in the central row of posts, which consist of angle irons. There are neither trays nor conduits, the cables are easily reshifted and examined and are kept cool. The slots, through which cables and pipes are passed, are opposite junctions in the pipe line, so that branches enter the laboratories at the level of the roof principals, in order to facilitate support. In the laboratories the pipes are brought down to within 6½ ft. of the floor where they end in the cradles already referred to. Each cradle is a rectangular timber frame, 6 ft. by 3 ft., suspended at four corners by two gas pipes and two pipes for compressed air. The other pipes are fixed in the cradle; they all end in T-pieces which are fitted with taps and nozzles differing in shape and colour to prevent mistakes; in some cases the outlets are fitted with screw-down valves.

Before proceeding to an outline of the work done in the laboratories, we should say a few words concerning the workshops. There are two, the metal workshop, shown in Fig. 4, on Plate XVII, and the wood workshop, opposite the former. These workshops not only supply the special apparatus wanted, but they engage in research work of their own, devising and improving automatic machinery and suggesting means of accelerating and perfecting the production.

To explain the way in which research is being conducted, we will first refer to the tungsten wire factory (see Fig. 8, on Plate XIX). The operations are there carried out essentially as in the works. The yellow tungstic acid, made from scheelite at Hammersmith, is at Wembley dissolved in ammonia in large heated silica jars, and is precipitated with hydrochloric acid. The precipitate is dried by suction, and the powdery mass is placed in one of the horizontal electric furnaces shown on the right-hand side of Fig. 8. The powder is placed inside a silica tube, 3 ft. long, which is wound with molybdenum wire. The tube is jacketed by another silica tube, and hydrogen is so circulated through the furnace that it flows through the inner tube and outside the outer tube. The heating lasts about four hours. The reduced powdery metal is next exposed to a pressure of 40 tons per sq. in. The hand pump used in the laboratory yields a bar, 20 cm. long, 5 mm. square, of friable metal, which is hardened by heating and then fritted by sending a current of 1,500 amperes, finally at 10 or 15 volts, through the bar, which is held vertically. The upper end is gripped by heavy copper jaws; the lower dips into mercury. This heating is carried out in a hydrogen atmosphere, within a cylindrical hood (see left-hand of Fig. 8). The bar is now swaged in a series of swaging furnaces, in which revolving hammers strike the bar. A pair of hammers consists of two flat pieces of tool steel so grooved that they grip the hot wire between them as it is pushed through the furnace hole. The operation takes a few seconds in each furnace. In the first furnace the bar is heated, by means of molybdenum wire coiled round an alundum tube, to 1,350 deg. C. As the wire gets thinner and longer, lower temperatures are sufficient, and the last swaging can be effected in a gas furnace, which delivers the wire into steel tubes, simply to get it out of the way. Thirty-five pairs of hammers are needed for the swaging process. The wire is then drawn through diamond dies in the ordinary way.

In spiralling the fine tungsten wire into filaments for gas-filled lamps, a wire of brass or steel is drawn through a hollow revolving spindle, which acts as a mandrel, on which the electrically heated filament is coiled in a close spiral. The mandrel is subsequently dissolved out by acid.

Straight wires for ordinary lamps are coated by being passed through the so-called "getter" solution which contains red phosphorus. When the wire is subsequently heated in the lamp, the evaporating phosphorus binds the residual gas and settles as an almost colourless compound on the inner bulb wall. This is the "clean-up" of high vacuum lamps.

In the experimental lamp factory (Fig. 5 on Plate XVII) a start is made with a piece of glass tubing. The one tube end is "flanged" by being heated in a blowpipe and opened out with the aid

of an arrow-shaped tool. Into the other end is sealed the glass lamp containing the electrode wires, and to this is fixed the stem holding the hooks for the filament. In the experimental valve factory (Fig. 7, Plate XVIII) the whole process of making thermoionic valves is similarly gone through, and the special features of various types of valves with multiple grids are being investigated.

To expel the gases from the metal parts of a valve, the metal is bombarded by cathode rays while the bulb is being exhausted. The evacuation is produced by means of a very simple, but effective, form of Gàede mercury diffusion pump. A glass bulb containing some mercury is heated over a gas burner; the bulb communicates with the valve by a lateral tube, ¼ in. diameter, and is connected with the rough pump at the top.

In the vacuum physics laboratory (Fig. 6 on Plate XVIII), X-rays, analysis of traces of gases, static charges in bulbs and other high-tension problems are studied. The lamp life-testing room (Fig. 9 on Plate XIX) is one of the few devoted to routine work. Some 800 lamps are simultaneously under test. They are of diverse types, and old-fashioned carbon lamps, neon lamps and strip lamps (for shop windows) may be neighbours.

In the first of two photometer rooms the suitable illumination of rooms and of advertisements is being inquired into. The second room serves for the more scientific work with the aid of a cubical photometer box, a Lummer-Brodhun head and other apparatus. Primary batteries are one of the chief studies of the chemical section, in which the draught cupboards are provided with false walls at the back; through slots in these walls the gases are drawn off into the flue into which compressed air is injected. The metallurgy, refractory and glass laboratories are as yet not fully equipped. As regards glass the viscosity problems of melting glass are being investigated with the aid of hot saturated, highly-viscous solutions of cane sugar.

The rules for the use of the spacious library (see Fig. 13, Plate XX) well deserve notice. A new periodical is, on its arrival, placed upon the library table for four days. To each journal is affixed a list of the chief members of the staff. If any of these wishes to have the journal in question for further study, it is afterwards sent to his office, where it may be retained for four days; after that period it has to be returned. Any member finding an article of particular interest draws up a brief abstract, which is submitted to the committee of four leaders, who check the abstract and have it typed on an index card, which is put in a box. Copies of these entries are forwarded to the Witton works.

We deal, in another article, on page 274 of the present issue, with the opening ceremony of the Laboratory on Tuesday last, and with the various demonstrations of work done which were then carried out for the benefit of the visitors.

LITERATURE.

The War in the Air. Being the Story of the Part Played in the Great War by the Royal Air Force. Vol. I. By WALTER RALEIGH. Oxford: The Clarendon Press, 1922. [Price 21s.]

A MELANCHOLY interest attaches to this volume, for the able mind and kindly spirit as well fitted to describe individual heroic deeds as to explain the complicated movements of armies, whether on land, or sea, or in the air, did not live to complete the task he had planned with consummate skill and on which he had worked with equal eagerness and success. The life of Sir Walter Raleigh was shortened by his devotion to his work. In order to acquire first-hand knowledge of the conduct of aerial warfare in the East, he visited Bagdad and while there contracted typhoid fever, which subsequently made an operation necessary, and he died but a few days after returning to England. He has left us a noble, if unfinished, monument to his energy and capacity. He has taught us how history—the history of adventure and of sacrifice—should be written: he has modelled the framework of a remarkable epic, and shown how the dry bones of official dispatches can be quickened into life and made to yield a worthy picture of the devotion and courage that animated the men, who conquered difficulties they could but imperfectly realise, and took risks where the penalty of failure was death.

At the outset Sir Walter reminds us how little we know of man's greatest achievements. We praise the man for his cunning and courage who first ventured in a crazy boat of his own contriving on the unstable ocean, but we do not know even the name of that man. His biography will never be written. Centuries of dreams and struggles and rash adventures went to the perfecting of that frail craft, but the whole story is beyond recovery "in the rapidly-closing backward perspective of time." In the conquest of the air, we have been witnesses of a drama as exciting in its development and as fertile in its consequences. We have seen in our own time what enterprise coupled with resolution can achieve. It is a duty to leave a record of what has been attempted and what has been accomplished, and it is this tale of courageous invention that the author sets out to tell, convinced that the history of the war in the air is inseparable from the history of the development of the art of flying.

For those who recall a few names in the past centuries, and are acquainted with some of the more striking episodes, separated by long intervals, there is no appearance of continuity in the theories and efforts that have from time to time startled the world by their boldness or appealed to the imagination as promising lines of possible development. The historian sees more truly and perfectly. The success attained is the realisation of a "long story of legends and dreams, theories and fancies" which genius, trained on continuous experiment, suddenly transforms into fact. The sketches of Leonardo da Vinci in which some think to see the beginnings of scientific aircraft are as much a piece of the story as the confidence of John Damian, who, greatly daring, sought to fly by means of wings of his own devising, but only succeeded in breaking his thigh-bone. Many worthy names figure in the list of adventures, some of whom demonstrated their courage rather than their knowledge, and some "who could better tell twenty what were good to be done, than be one of the twenty to follow their own showing." Later in time, came the balloons of Montgolfier and of Charles, who sought to accomplish their object by other means and who may be regarded as the pioneers of another school. The rivalry between the supporters of the aeroplane and the balloon is not ended yet. "The arrow and the soap bubble," to use Sir Walter's simile, have ardent advocates, and it may be that the world will find a place for each, both in war and in transport.

The scene changed when, on December 17, 1903, less than twenty years ago, Wilbur Wright made the first sustained flight. The thing was done, the dreams of enthusiasts were realised. A machine existed that could fly, and the later introduction of an engine and other accessories was as simple a matter as the harnessing of a horse to a carriage, though it may be mentioned that the Wrights had a difficulty in getting a motor made to their own specifications, and finally constructed it with their own hands. But they had succeeded in demonstrating the functions of a movable vertical tail in a flying aeroplane; they had shown how wings adjustable to different angles of incidence could be used in combination with the vertical tail to control the balance and the direction of the machine. Doubt was replaced by confidence, and a host of experimenters were in the field. No new generic principle has since been introduced; attention has been fixed on details. By the end of 1908, long-distance flights were frequent, and the Wrights entertained hopes of selling their invention to Government for war purposes. But the Government held aloof, the Navy especially was slow to grasp at new weapons before their value was proved. Up to the end of 1911, the policy of the Committee of Imperial Defence with regard to all branches of aerial navigation was based on a desire to keep in touch with the movement rather than hasten its development. It was felt that we stood to gain nothing by forcing a means of warfare, which tended to reduce the value of our insular position and the protection afforded by our sea power.

In the middle period, is traced the means by which science and patience achieved the mastery of the air. It is one of the many merits of this work that equal acknowledgment is made to those who made aerial warfare possible, and to those who by application of the perfected machinery carried to a successful issue the novel methods so recently evolved. Similar sacrifices were exacted from both and as willingly paid, whether in the experimental field or in the ranks of war. Many names familiar as household words a few years since, but now on the road to oblivion, have their claims pressed on us. The contribution of the patient experimenter in testing the efficiency of gliders is commemorated in the work of Lilienthal and of Pilcher, both of whom gave their lives to the cause. In another field, mathematicians like Langley in America and Bryant in England, kept attention strictly on the problem that had to be solved, and insisted on the importance of attacking these problems scientifically. To Langley we doubt if public opinion has rendered justice. His work on the internal energy of the wind is a classic, and his demonstration of the fact that the greater the velocity given to a plane, the less the force required to sustain the plane, gave enormous impetus to the work of experiment, and prominence to the advantages of the aeroplane over the airship. In his actual attempts at flying Langley was unfortunate, and accident robbed him of much of the credit that was his due. Probably he was unskilled in mechanical adjustment, and his temperament could not brook the criticism of smaller men and the ridicule of ignorance. But since his death, we believe his original machine has been repaired and has demonstrated that with skilful handling his device was capable of all that he claimed for it. We might recall many other typical names that figure in the early history of flying, but final success was attained rather by the courage of the many than the devotion of the few. The spirit of sportsmanship was awakened and the call on heroism and nerve was answered with eagerness. We were rich in engineering skill and in material for the struggle. "We had a body of youth fitted by temperament for the work of the air, and educated, as if by design, to take risks with a light heart—the boys of the Public Schools of England." Henceforward the work of the individual disappears in that of societies in which mutual encouragement and the fellowship of adventure played a leading part. Brooklands, after some opposition, became a training ground; Eastchurch and Larkhill followed, duty and training superseded individual effort, and the Royal Flying Corps took shape early in 1912. The names of those who deserve credit are "thick as the motes that people the sunbeam" and the author's tireless industry is unequal to the task of doing justice to those who claim attention. He is reported to have said, "Some authors expect fame: I shall be satisfied with forgiveness."

This careful preparation and construction make evident not only that at the outbreak of war the country was in possession of "a small but healthy service," both naval and military, ready to take the air, but of the quality of the material of which it was composed and its fitness to discharge the duties asked of it. Four squadrons or 48 machines with a very small reserve, formed the military wing and played a worthy part in assisting the army during the retreat from Mons, and the depressing time that immediately followed. The naval branch of the service was sent to Belgium, took part in the defence of Antwerp and subsequently established itself at Dunkirk, a port that was destined to become an important centre in aerial operations. Some 250 officers all told were sufficient for this arm of the service. How this nucleus multiplied, so that four years later 30,000 were needed is the marvellous story that Sir Walter Raleigh designed to unfold. Certainly, money and energy were expended without stint, and picturing what was accomplished in so short a space of time it may be doubted, "whether in the whole history of mankind, any art in its infant stage, has been so magnificently supported and advanced by war, as the art of flying was supported and advanced by the greatest war of all wars."

Very little is told of the war in this volume. The strategy and movement of forces in Belgium as seen from the air is described, and the value of the new arm is amply demonstrated, though in the early days there were many mistakes owing to the want

of military knowledge and the need of practice in reading the appearance of things seen from the air. The German reports seem to have been as inaccurate as our own, for Von Kluck was misled by his observers into believing that the British Army after retreating from Mons would make a stand at Maubeuge. The interest is personal and biographical rather than military, centreing in the details of the reports from the several squadrons, and the use that was made of the information. Into this mass of material, Sir Walter infuses life and animation while strictly adhering to official documents. Many memorable episodes, sternly repressed or only imperfectly reported at the time are thus preserved in history, the quotations from the reports testifying to the gallantry and devotion of the individual members over whose work and capacity the author lingers with evident fondness. Every page brings its startling tale of danger faced with fearlessness, or gives evidence of swift decision on the part of youthful officers, or of readiness of resource under difficulties, that compel our admiration and respect. Youth comes into its own here. No hoary precedents fetter its conduct, it makes its own rules and supplies its own traditions. "The story, if it could ever be fully and truly written, would be the Epic of Youth."

BOOKS RECEIVED.

*The **Manual of Up-to-Date Organisation and the Science and Practice of Cost and Works Accountancy.*** By G. T. TURNER and B. WOOD. London: The School of Costs and Works Accountancy. [Price 10*s.* 6*d.* net.]

Wechselstromerzeuger. By Professor Dipl.-Ing. FRANZ SALLINGER. Berlin and Leipzig: Walter de Gruyter and Co.

Department of Scientific and Industrial Research. Manchester Association of Engineers. Report of the Lathe Tools Research Committee. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 5*s.* 2*d.* post free.]

Aeronautical Research Committee. Reports and Memoranda No. 794. *The Aerodynamic Loading of Airships.* By Professor L. BAIRSTOW, C.B.E., F.R.S. London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 3½*d.* post free.]

Industrial Hygiene and Medicine. By E. W. HOPE, O.B.E., M.D., D.Sc., W. HANNA, M.A., M.D., D.P.H., and C. O. STALLYBRASS, M.D., D.P.H. London: Baillère, Tindall and Cox. [Price 25*s.* net.]

The Manufacture of Lubricants, Shoe Polishes and Leather Dressings. By RICHARD BRUNNER. Translated from the Sixth German edition by H. B. STOKES, F.I.C., F.C.S. London: Scott, Greenwood and Son. [Price 10*s.* 6*d.* net.]

Fabrication de L'Acier au Four Martin. By A. BARBEROT. Paris: J. B. Baillière and Fils. [Price 40 francs.]

Who's Who, 1923. London: A. and C. Black, Limited. [Price 42*s.* net.]

Aeronautical Research Committee. Reports and Memoranda. No. 792. *The Reduction of the Effective Value of Young's Modulus in Flexible Compression Members.* By A. J. SUTTON PIPPARD, M.B.E., D.Sc. [Price 3½*d.* post free.] No. 798. *Air Consumption and Brake Horse-Power of Aero Engines.* By H. MOSS, M.Sc., D.I.C. [Price 1*s.* 4*d.* post free.] No. 804. *Tandem Aerofoils.* By J. L. NAYLER and W. L. LE PAGE. [Price 7*d.* post free.] London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office.

Les Moteurs Diesel et les Moteurs Semi-Diesel. Types Fixes et Types Marine. Théorie Description Combustibles, Construction, Conduite, Avaries, Entretien. Vols. I and II. By G. VAILLOT. Paris: Dunod. [Price 180 francs net.]

The Association of British Chemical Manufacturers' Official Directory of Members with Classified List of their Manufactures, 1923. London: Offices of the Association. [Price 10*s.* 6*d.*]

Generalised Linear Perspective. Treated with Special Reference to Photographic Land Surveying and Military Reconnaissance. By J. W. GORDON. London: Constable and Co., Limited. [Price 21*s.* net.]

The "Mechanical World," Electrical Pocket Book, 1923. Manchester and London: Emmott and Co., Limited. [Price 1*s.* 6*d.* net.]

Coke for Steam Raising Purposes and Some Other Means of Increasing its Sale. By GEOFFREY M. GILL. London: Walter King, Limited. [Price 1*s.* 6*d.* net.]

Optical Methods in Control and Research Laboratories. Vol. I. By J. N. GOLDSMITH, Ph.D., M.Sc., and others. London: Adam Hilger, Limited. [Price 1*s.* 6*d.* net.]

The World's Timbers for Building, Furniture and Construction. (Incorporating Building Timbers.) By JAMES DAVIES and others. Second edition. London: Alfred Haworth and Co., Limited. [Price 5*s.* net.]

The Practical Testing of Dynamos and Motors. By CHARLES F. SMITH, D.Sc., M.I.E.E. Ninth edition, Manchester: The Scientific Publishing Company. [Price 7*s.* 6*d.* net.]

Heizungs-und Luftungsanlagen in Fabriken. By VALERIUS HUTTIG. Second edition. Leipzig: Otto Spamer. [Price 10,500 marks, plus 200 per cent.]

Mathematics for Engineers. Part II. By W. N. ROSE, B.Sc. Second edition. London: Chapman and Hall, Limited. [Price 13*s.* 6*d.* net.]

MULTI-CUTTING TOOL ARRANGEMENTS.

By JOSEPH HORNER.

(*Continued from page* 165.)

Multiple Spindle Machines.—These approach the subject of tooling from a standpoint which is the opposite from that of the turret lathes. The tools are carried in the spindles, while the work is held stationary in the turret. The latter advances and feeds the pieces of work which it holds against the tools rotated in the spindles. The turret carries several pieces which are brought each in turn into line with succeeding spindles. As in ordinary turret work, the time necessary to complete a piece is measured by the period required for the longest single operation on it. The axis of the turret barrel is the centre of the work-holding sections of the turret. The centres of the tool spindles are aligned with all but one of the turret section centres. One is missed in order that the chuck section there shall be brought opposite to where there is no tool, so that the attendant shall load and unload at that locality without stopping the machine. Several of these machines are made in different models, but designed on the principle stated. A cycle of operations is thus carried through on several pieces of work at the same time, each operation contributing its share to the completion of the piece. The difference between this and the common turret lathe is that frequently the numbers of cutting tools in action at one time are increased. There will be as many tools as there are spindles, and frequently several tools are carried in a spindle head.

The New Britain Machines.—Some examples of work are shown done on the machines by the New Britain Machine Company, of New Britain, Conn., U.S.A. These are built in two distinct types, the single and the double head. The first, Fig. 65, are designed for the performance of operations on one end only at a time. The second operate on both ends at once, so saving one-half the time occupied in the first, provided both ends have to be tooled, as usually happens. In the single-head machine the work-carrying turret advances against the tools. In the double-head design, the turret occupies the centre of the bed, and the revolving tools advance from opposite sides, to operate on each end of the work. The number of spindles varies in different machines, ranging from three to eight. In Fig. 65 there are four working spindles, and five chucking positions.

The turret is mounted on one end of a rigid barrel, which turns and slides in bushed bearings. At the other end, an indexing mechanism seen in the photograph automatically locates the turret in its different positions. A large cam drum below the turret barrel is revolved by a worm gear. Camming strips set on the outside of the drum act against a hardened steel roller on a yoke which can be clamped in any position on the barrel to suit work of different lengths. The cams are so shaped and set as to throw the turret quickly forward and back to clear the tools at the time of indexing. A stop screw on one side of the turret yoke accurately gauges the forward movement of the turret. All turrets have, as stated, one more chucking section than there are tool spindles, which permits of unloading and loading while the tooling operations are proceeding on the others. The single-head machines have from four to five working spindles, in different sizes and capacities.

In the double-head machine, the multiple chuck turret located midway between the two sets of spindles is mounted, and indexed on a central shaft with the indexing mechanism at the extreme right hand of the bed. The turret has no longitudinal

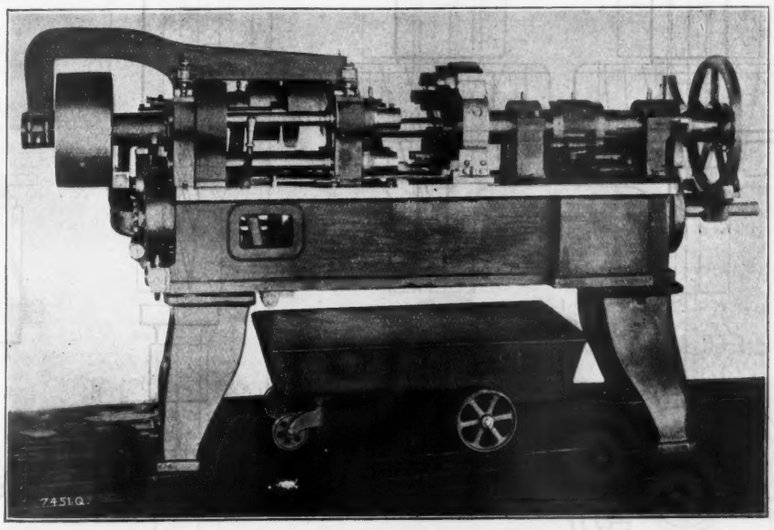


FIG. 65. MULTIPLE SPINDLE MACHINE; THE NEW BRITAIN MACHINE COMPANY.

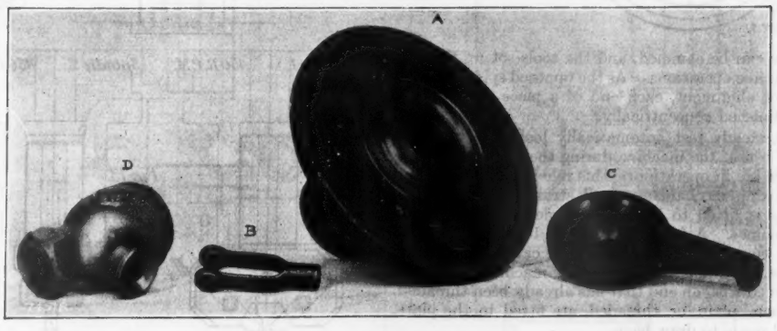


FIG. 66. EXAMPLES OF WORK CARRIED OUT ON MULTIPLE SPINDLE MACHINE.

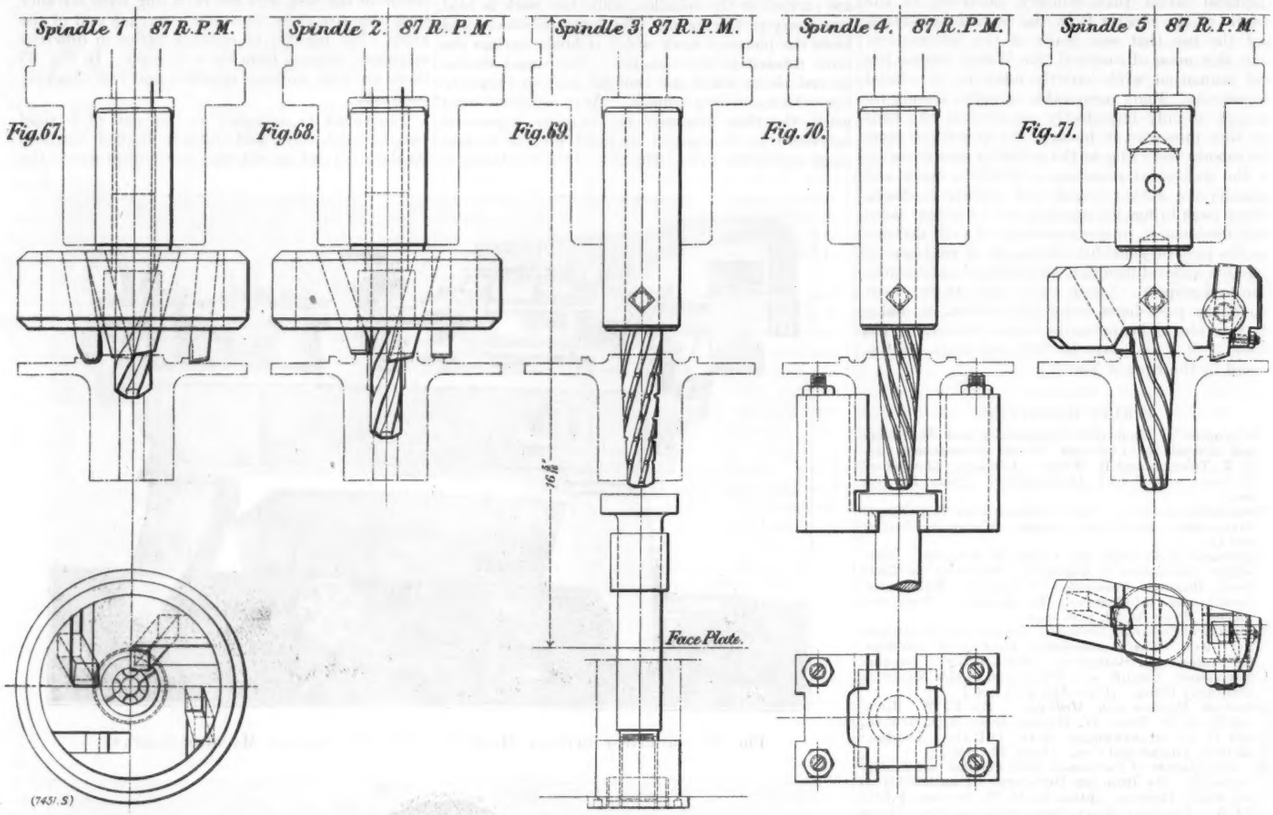
motion, but the flanking spindles are fed towards it with independent cams. The cam drives are situated directly below each group of spindles, and are mounted on a shaft driven by worm gear at the extreme left of the machine. The cam strips act against hardened steel rollers on the spindle yokes. Since the two groups of spindles are independent, they can be cammed, and the tools set up for like, or unlike operations. As the opposed spindles are in strict alignment, each end of a piece of work will be finished concentrically.

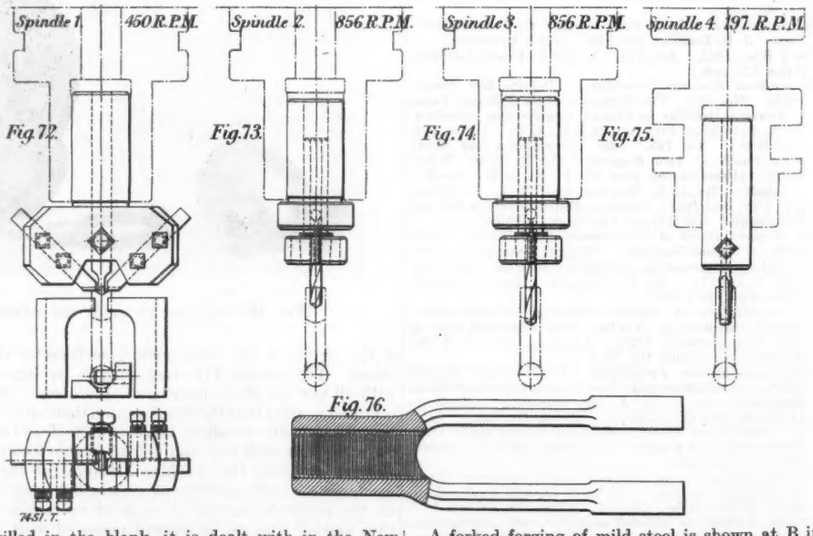
A steady rest automatically locks the turret to the bed of the machine during the period when the tools are in operation. This relieves the barrel and indexing mechanism of all strain during cutting. This is fitted to both the single and double-head machines. A face plate has to be substituted for the turret in cases where work cannot be held in jaws, or when the end being machined must be aligned with an end that has already been threaded. Arbors, plain or threaded, are fitted in the plate, and made to draw back.

The ordinary chuck jaws in the turret are prepared to suit the work. These are received in hard jaws of tool steel, fitted in the turret, and opened and closed simultaneously with a right and left-hand screw having a square end for a wrench. Each chuck is independent of the others. The work of release and insertion is done rapidly.

The combination of tools for drilling and reaming, with those for cross-feeding, is effected by the hollow spindle design. The spindles are drilled through their entire length for the insertion of tool-adjusting rods which permit of making delicate settings of the tools, and of affording them a solid backing to withstand the thrust of the work. If these rods are removed, high-speed spindles with bronze bearings and ball thrust collars can be inserted. The drive is applied to the rear ends of the spindles by means of gears, or of an independent pulley. The cross-feeding for the other tools is effected by mounting them in a cross-sliding head attached to the spindle. The tools are operated by the thrust of the work acting against two angular wedges which are made with the proper angle to give a slow, or a fast cross-motion to the cutter head. This motion draws the cutter down into the work, and when the work starts to back off, a spring in the hollow spindle forces the cutter head out on the wedges, and the tool out of the work.

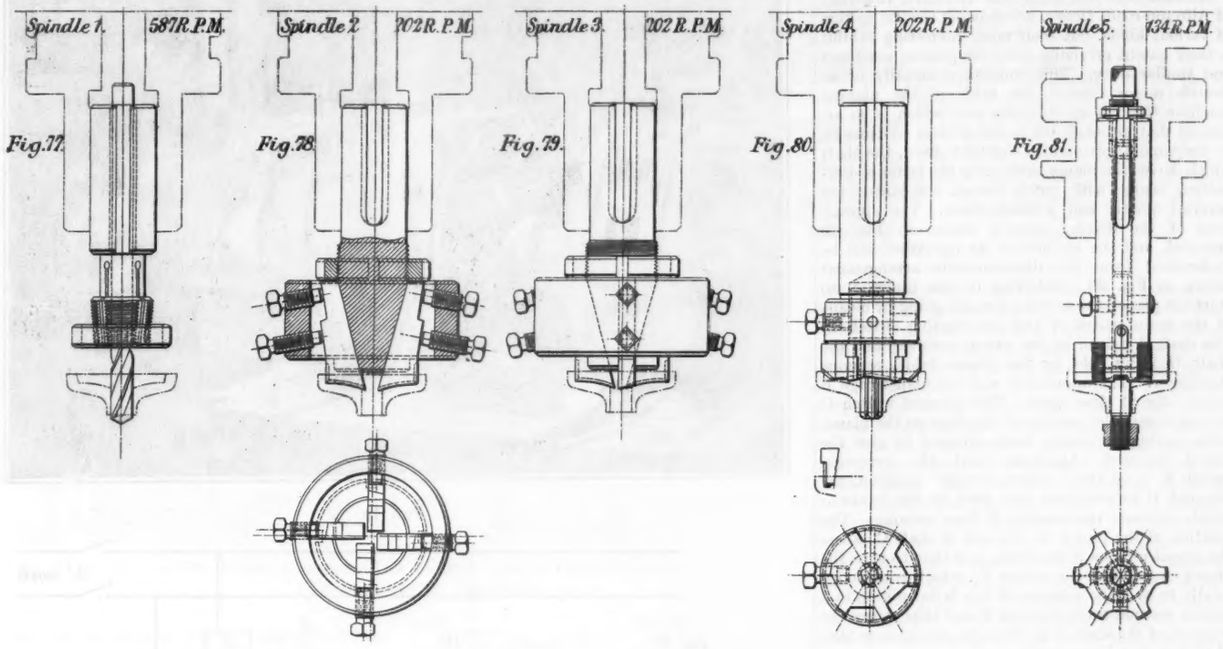
Examples of Work.—The first group of illustrations below shows the tooling of an automobile rear hub—a mild steel forging. It is shown in the engraving, Fig. 66, at A. A small centre hole having been drilled in the blank, it is dealt with in the New Britain machine in the successive stages illustrated by the drawings, Figs. 67 to 71. These drawings are arrangements in plan, looking on the work from above, the spindles being disposed as stated, horizontally. In the first and second stages, Figs. 67 and 68, a core drill enlarges and deepens the hole previously rough-drilled, the second drill, which is smaller than the first, going deeper, both roughing the hole in steps to be tapered in the next stages. During these operations, the face of the hub at the centre is being grooved and faced, and the shoulder being faced and turned. Three tapered reamers follow, two having flutes of different hands, Figs. 69 and 70, for coarser and finer cuts, and both notched to break up the chips. A final reamer, Fig. 71, of the floating kind finishes. Tools in a head take finishing cuts off the faces. For these operations the production is 60 per hour. The spindles are all run at the same speed—87 r.p.m.

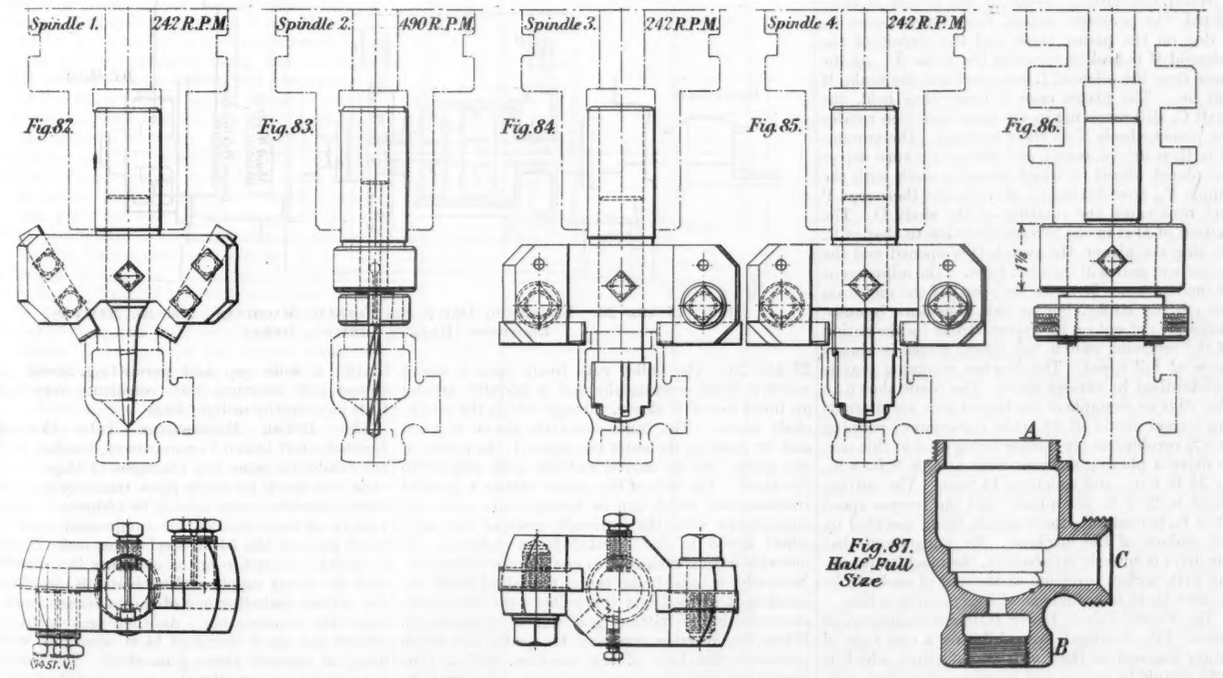




A forked forging of mild steel is shown at B in Fig. 66, and by the drawing Fig. 76. It is drilled from the solid, faced, chamfered and finished at one setting at the rate of 200 pieces per hour. The single longest operation is the tapping, and the piece is finished in the time occupied by that. In the first stage, Fig. 72, the piece is centred and gripped in the chuck, the hole started and coned with a central tool in a head, and faced with two tools in the head, the spindle making 450 r.p.m. In the two succeeding stages of drilling, Figs. 73 and 74, the spindles make 856 r.p.m. In the last stage, that of tapping, Fig. 75, the spindle speed

is 197 r.p.m. The tap used is a two-flute form, with a long lead to enable practically a full thread to be cut with one pass through, by throwing the chips ahead.





The next example is a phonograph part C, in Fig. 66—a bronze forging, the product of which is 230 per hour. Note should be made of the three different spindle speeds to permit of employing each tool to the best advantage; also the use of a leader on the tap which cuts a fine thread of 40 to the inch. In the first stage, Fig. 77, the hole is being drilled with the spindle making 587 r.p.m. In the next, Fig. 78, two flat cutters form the interior at a speed of 202 r.p.m., the depth of the recess being determined with a stop nut on the cutter holder. At the third stage, Fig. 79, a finish forming cut is taken at the same speed and in the same manner. In the next, Fig. 80, the hole is reamed at the same speed. In the fifth stage, Fig. 81, the fine thread of 40 to the inch is tapped at 134 r.p.m., guided by the small leader tap.

The last example is that of the tooling of a valve body, D in Fig. 66, and the drawing Fig. 87. The production is 280 pieces per hour for the operations shown. Here also different spindle speeds are employed. The valve body is gripped in a chuck made specially for it, but not shown. A flat drill in the spindle, Fig. 82, rough bores the interior, and two cutters on the head chamfer the edge, the spindle making 242 r.p.m. Still working on the same end, a twist drill produces the central hole, Fig. 83, at 490 r.p.m. In the next stage, Fig. 84, a forming tool in the spindle shapes the bottom seating, and two tools in the head cut the outer shoulder, the spindle making 242 r.p.m. Next, Fig. 85, the interior is finished, and the outside finish turned at 242 r.p.m. The neck is threaded finally, Fig. 86. In another chucking the opposite end is faced, chamfered, bored and tapped at 322 r.p.m., with a rate of production of 500 per hour. The branch, Fig. 87, is dealt with at the same rate and speed. It is turned, faced, chamfered, seated and threaded.

(To be continued.)

ENAMELLED WARE IN CHINA.—The Chinese Government Bureau of Economic Information states that whilst there are several factories manufacturing enamelled ware in Shanghai and Tientsin, China depends on foreign countries to supply her needs. A great variety of enamelled articles for domestic use are imported every year. Enamelled ware was first introduced by the Germans and later supplied by the Japanese who, during the war, fell heir to the German trade. Since the war the Germans have again entered the field.

THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.

(*Continued from page* 232.)

MESSRS. NEWTON BROTHERS (DERBY), LIMITED, of Alfreton-road, Derby, are showing electric motors of various kinds, but their most interesting exhibit is their patent reversing drive for planing machines and similar duty. This consists essentially of an electric motor driving the table of the planing machine through an epicyclic gear which is so arranged that although the motor rotates continually in the same direction at a constant speed, the shaft which drives the planer table gives the latter a slow-cutting stroke with quick return, and effects the reversal quietly and without shock. The appearance of the driving gear is shown in Fig. 19 annexed, and the method of its operation will be understood from the diagrammatic arrangement shown in Fig. 20. Referring to this diagram, to start the planer, the motor is first set going by means of the main switch A and the starting switch B. The shaft C, driven by the motor, revolves, and the shaft D being held by the planer table, remains stationary. The annulus E and the planet cage F rotate idly at slow speed. The solenoid switch G is then closed, the position of the dogs on the planer table having previously been adjusted to give the travel required. Assuming that the reversing switch K is on the "cutting-stroke" position, the solenoid H is energised and puts on the brake J which prevents the annulus E from turning. The rotation of the pinion on the end of shaft C causes the planet pinions N to rotate, and thus to turn the planet cage F and the pinion F_1, which is attached solidly to it. The rotation of this latter pinion in a similar manner turns the cage P and thus causes the rotation of the shaft D in the same direction as that of C, but at a lower speed.

When the cutting stroke of the planer is completed, the reversing switch K is thrown over by a dog on the planer table and the circuit of the solenoid H is broken releasing the brake J. At the same time the solenoid L is excited and the brake M put on. The planet cage F being thus held, the shaft C, still revolving in the same direction rotates the planet wheels N on their bearings. The annulus E is then driven round, and this in its turn drives the planet wheels O, which being in mesh with the pinion F_1, now stationary, drive round their cage P and thus cause the rotation of the shaft D. The motion of D is in the reverse direction to that of C. To stop the planer, the switch G is opened and the motor and gear will then run light. The adjustment of the resistance R varies the speed of the motor on the cutting stroke, but as this resistance is automatically cut out on the return stroke by the action of the reversing switch, the return stroke is always made at full speed. The Newton reversing gear is standardised in various sizes. The plant shown in Fig. 19 is an example of the largest size, an alternating-current motor of 60 brake horse-power running at 575 revolutions per minute being used in this case to drive a planing machine with a table 9 ft. 8 in. by 15 ft. 6 in., and weighing 16 tons. The cutting speed is 23·3 ft. per minute and the reverse speed 97·5 ft. per minute, these speeds being specified by the makers of the machine. We understand that the drive is entirely satisfactory, the machine reversing with perfect precision at the end of each stroke so that there is no danger of overrunning a line.

The Fraser Patent Power Hammer Company, of Leven, Fife, Scotland, are exhibiting a new type of power hammer of their own manufacture, which is both simple in design and inexpensive in first cost. It is suitable for all kinds of tool smithing, as well as for forging, stamping and straightening work within the capacity of its various sizes. The mechanical features of the hammer will be understood from Figs. 21 to 24, on page 263. The steel hammer-head which is of cylindrical form, contains a buffer spring, the latter forming an elastic connection between the head and the plunger rod. This rod is caused to reciprocate by a crank-pin working in a slotted link. The crankshaft is driven by a belt pulley connected to it by means of a friction gear which is put into action as desired by the depression of a pedal-bar by the foot of the operator. Details of the friction drive are illustrated in Figs. 23 and 24. The pulley runs freely upon a sleeve which is bored eccentrically and is movable around an inner eccentric sleeve, through which the crankshaft passes. The inner eccentric sleeve is fixed and by rotating the outer one upon it, the centre of the pulley can be moved radially with respect to the shaft. The web of the pulley carries a grooved friction-drum which can be brought into or out of engagement with the internally-grooved rim of a wheel keyed to the crankshaft by rotating the movable eccentric sleeves in one or other direction. Normally, a band brake round the wheel holds the crankshaft at rest, and the pulley runs idly on its sleeve with the friction gear out of engagement. When the operator depresses the pedal bar which surrounds the base of the machine, and is thus convenient for use wherever the operator may be standing, the vertical rod shown in Fig. 21 is raised against the action of a long helical spring. This rod is connected at its upper end to a lever extending from the movable eccentric sleeve, and it also carries an arm which holds the end of the band brake Hence when the rod is raised by the pedal action, the brake is released and the eccentric sleeve is simultaneously rotated, thus bringing the friction grooves into contact and causing the hammer to work. The force of the blow delivered by the hammer is dependent upon the extent to which the pedal bar is depressed. Hammers of the type described are built in three sizes, which cover all ordinary ranges of work. They occupy very little floor space, and having a wide gap and permitting access from almost any direction, they constitute very useful tools in a smithy or light forge.

The British Mannesmann Tube Company, Limited, of 67 Queen Victoria-street, London, E.C.4, are exhibiting some fine examples of ships' davits, expansion bends for steam pipes, tramway poles, &c., made of weldless steel tubing, in addition to a great variety of steel bottles for compressed gases. A short piece of the 54-in. steel water main 27 miles in length, ordered from the company in connection with the water supply of Manchester is also shown, the portion including one of the joints sectioned to show the construction. Another very interesting exhibit is a short length of 14-in. steel pipe with a lining of concrete about $\frac{3}{4}$ in. thick. The concrete is applied by a centrifugal process, and the lining is of even thickness with a surface finish equal to that of an ordinary cemented surface. The same process has been applied to steel pipes, 28-in. diameter, with a shell thickness of $\frac{1}{4}$ in., the lining in this case being $\frac{1}{8}$ in. thick. These pipes have been designed for the Cardiff water supply, the idea being to protect the steel from the action of the soft water of the district.

The stand of Messrs. William Kenyon and Sons, Limited, of Dukinfield, near Manchester, is chiefly occupied with cotton driving ropes, lifting ropes of cotton, manilla and hemp, and cordage string and twine of all descriptions. They also show appliances for drilling and tapping gas and water-mains under

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

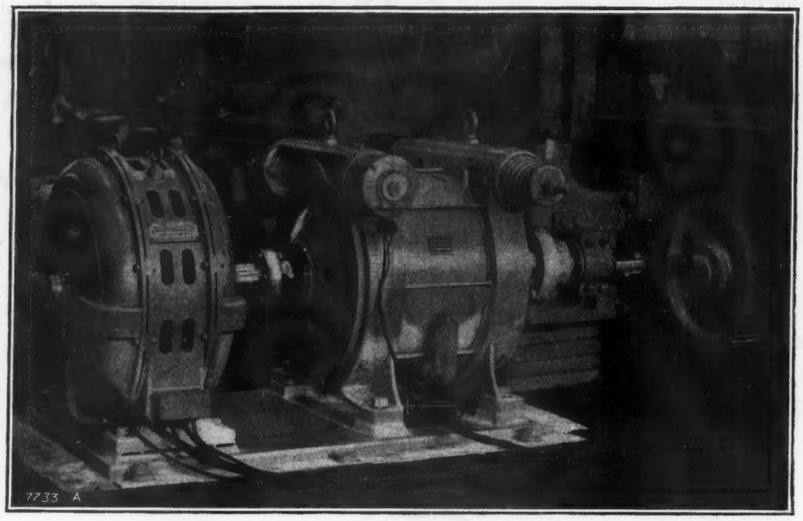
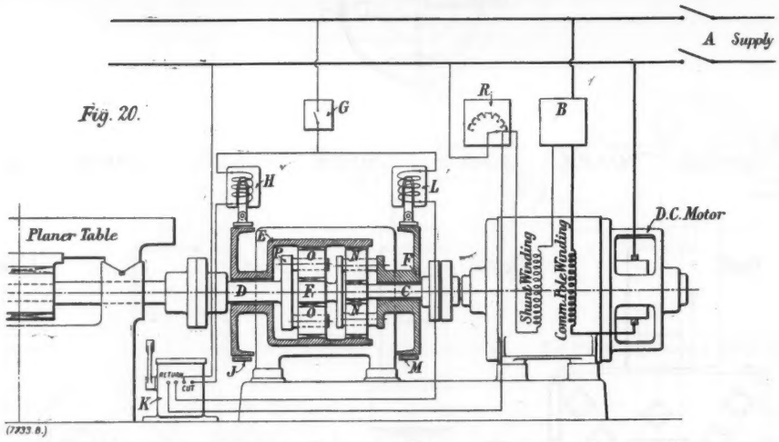
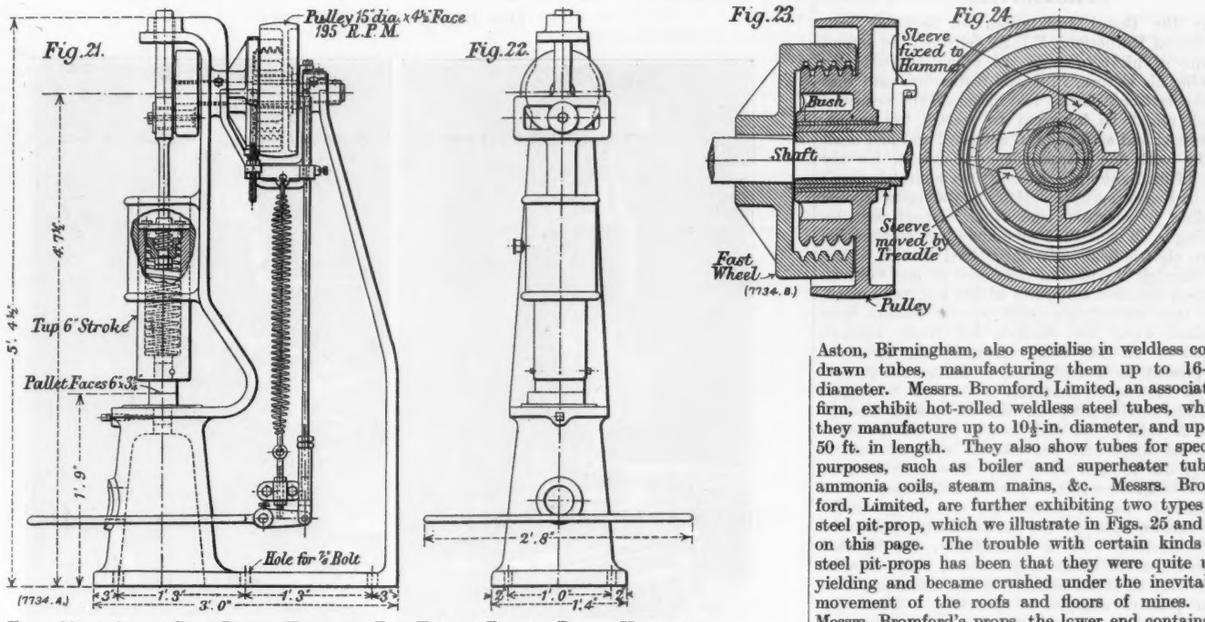


FIG. 19.



FIGS. 19 AND 20. REVERSING DRIVE FOR PLANING MACHINES; MESSRS. NEWTON BROTHERS (DERBY), LIMITED, DERBY.

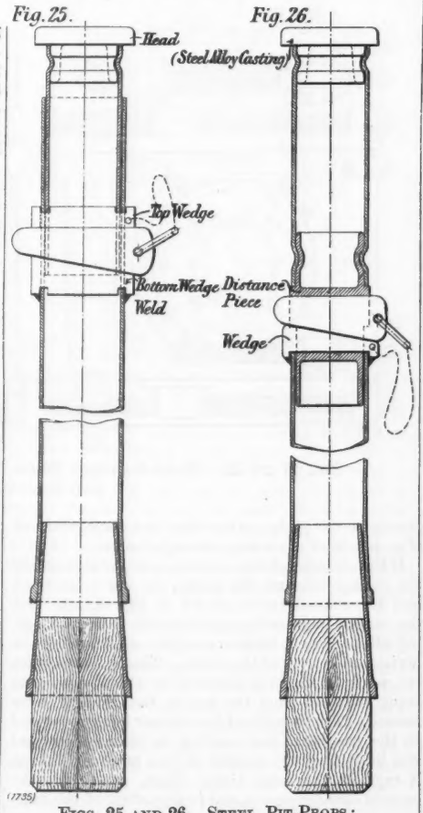
EXHIBITS AT THE BRITISH INDUSTRIES FAIR AT BIRMINGHAM.



FIGS. 21 TO 24. 1-CWT. POWER-HAMMER; THE FRASER PATENT POWER-HAMMER COMPANY, LEVEN, FIFESHIRE.

pressure. In one form of this a cylindrical casting split along the centre line, is clipped round the pipe. One part of the casting carries an extension forming a guide and stuffing-box for the drill spindle, which is turned by a ratchet brace and fed forward by a screw, the whole apparatus being self-contained. The drill used is really a hollow mill or trepanning tool, and it is followed by a tap on the same spindle, so that drilling and tapping are both performed before the tackle is removed. In a lighter form of the appliance a saddle carrying the drill and guide is held to the pipe by a sprocket chain which passes round the latter. Heat-insulating coverings for boilers and steam pipes are also to be seen on the stand.

Messrs. Automatic & Electric Furnaces, Limited, of 173 to 175, Farringdon-road, London, E.C.1, are exhibiting a number of examples of the Wild-Barfield electric furnaces in actual operation. These furnaces are designed especially for the correct hardening of steel, and their peculiar feature is that they indicate to the operator the moment when the proper hardening temperature is reached. This temperature, of course, is that at which the second of the constitutional changes takes place in the steel with the formation of cementite, and hardening depends upon the preservation of this cementite by cooling the metal too quickly to permit of the change being reversed. The critical point, known at the AC_2 point, is about 760° C., and above this temperature not only can the steel be hardened, but simultaneously its magnetic properties disappear. The concurrence of these two phenomena is taken advantage of in the Wild-Barfield furnaces. The latter are resistance furnaces in which a refractory muffle is heated by the passage of an electric current through a coil of resistance wire with which the muffle is closely wound. Surrounding the heating coil is another winding which is balanced against an external coil mounted on a control board, in such a way that when there is no iron in the furnace an ammeter in circuit points to zero. The introduction of a piece of steel alters the inductance of the detector winding round the furnaces and so unbalances the system and causes a reading on the galvanometer. As soon as the steel reaches the hardening temperature, its loss of magnetic properties restores the balance of the system and the ammeter at once returns to zero. If the operator now quenches the steel, he will secure the best hardening possible for that particular sample. The furnaces are made in various sizes, both horizontal and vertical, and they can be used with either alternating or direct current. Pyrometers and excess temperature cut-outs are supplied with them if desired.



FIGS. 25 AND 26. STEEL PIT-PROPS; MESSRS. BROMFORD, LIMITED, BIRMINGHAM.

Messrs. Accles and Pollock, Limited, of Oldbury, Birmingham, show a large number of samples of weldless cold-drawn steel tubing to illustrate the extraordinary range of sizes and of cross-sectional shapes, which can be produced by the method indicated. Messrs. Tubes, Limited, of Rocky-lane, Aston, Birmingham, also specialise in weldless cold-drawn tubes, manufacturing them up to 16-in. diameter. Messrs. Bromford, Limited, an associated firm, exhibit hot-rolled weldless steel tubes, which they manufacture up to 10½-in. diameter, and up to 50 ft. in length. They also show tubes for special purposes, such as boiler and superheater tubes, ammonia coils, steam mains, &c. Messrs. Bromford, Limited, are further exhibiting two types of steel pit-prop, which we illustrate in Figs. 25 and 26 on this page. The trouble with certain kinds of steel pit-props has been that they were quite unyielding and became crushed under the inevitable movement of the roofs and floors of mines. In Messrs. Bromford's props, the lower end contains a removable socket pipe, into which a tapered wooden plug is tightly driven. This plug takes the weight of the roof, and when it becomes forced into the socket by the pressure, the pit prop is taken out and a new end-piece substituted, the old one being refitted with new wood at leisure. The pit-prop can be withdrawn by knocking out a cotter which allows the prop to collapse.

Messrs. G. Twigg and Son, 57 to 63, Moseley-street, Birmingham, are showing a hand-operated screw-press adapted for sinking dies, cutting punches and other difficult and accurate work of the tool-room. The press, as set up for two different classes of work, is shown in Figs. 27 and 28 page 264, while the adjustable work-table used in conjunction with it is illustrated in Figs. 29 to 32. This work-table, or machine vice, as the makers call it, is essentially a compound slide-rest with hand traverse in two directions at right angles, and a circular traverse to the central part. All traverses are indexed, the screw dials having 125 divisions, which allows of setting to 0·001 in. as the screws have eight threads per inch. The travel of the bottom slide is 9½ in. and that of the cross-slide 3½ in. The circular table is 6 in. diameter, and is removable, so that it can be replaced by special tables if required. For slotting irregular curves, the circular table is set free and moved by hand as desired. It is claimed, and no doubt with justice, that a hand-operated machine is both faster and safer than any power-operated machine on very small and accurate work. because the operator can "feel" the cut and work with safety to a dead end. In Fig. 27 the tool is shown held directly beneath the ram of the machine, a method which is quite adequate for many kinds of work. Messrs. Twigg and Son, however, also supply relieving tool holders, which prevent the cutting edge of the tool being dulled by being dragged over the work on the return stroke. A holder of this kind, for deep internal work, is shown in Fig. 28. Many samples on the stand illustrate the variety and difficulty of the jobs which can be carried out by these hand-presses. Multiple punches of complicated shape are shown cut from the solid, instead of being built up of individual punches fixed in a plate, and the whole display is well worth the attention of press-tool-makers and die-sinkers.

(To be continued.)

BARTLETT SCHOOL OF ARCHITECTURE.—Two entrance exhibitions, of the value of £40 a year each, tenable for not less than three years and not more than five, at the Bartlett School of Architecture, University of London, will be awarded in June next. Full particulars in reference to the matter may be obtained from the Secretary, University College, London, W.C.

ATOMIC PROJECTILES AND THEIR PROPERTIES.

AT the Royal Institution, on Saturday last, Sir Ernest Rutherford, F.R.S., delivered the second lecture of his course on the above subject. In opening his lecture, Professor Rutherford said that on the last occasion he had discussed the velocities which might be imparted to matter by various terrestrial and astronomical agencies, and had dealt briefly with the impact of what might, for the sake of distinction, be called "mechanical bodies." He had also made mention of the great speeds attained by electrons and other charged particles moving in an exhausted tube under the acceleration of an electric field. He had stated that in a free fall through a potential difference of one volt, an electron acquired a velocity of 595 km. per second, and that exceedingly high speeds indeed, were attained when the electron fell freely through 10,000 or 100,000 volts. Disregarding these for the present, he now proposed to discuss the properties of "low-speed electrons"—that was to say, of electrons moving with velocities due to a fall through some 25 volts or so, and having, therefore, speeds of about 3,000 km. per second, and the kinetic energy due to such a free fall. The study of these "slow" electrons had within the last decade added enormously to our knowledge, and in particular had thrown light on the excitation of spectra by swift electrons. As a preliminary, the speaker showed a model of an oxygen atom, which was, he said, built up of an excessively small nucleus, with eight positive charges of electricity. When the atom was in the neutral condition, this nucleus was surrounded by eight electrons, moving in different orbits at different distances from the centre. Two of these electrons, known as the K electrons, revolved in orbits near the nucleus. One of these moved in a nearly circular orbit, and the other in another orbit, the plane of which made an angle of 120 deg. with that of the orbit in which its fellow revolved. Further out were four electrons nearly equidistant from the nucleus, and moving in elliptical orbits, whilst the outermost electrons described circular or possibly elliptical, orbits. Since the orbits underwent cyclical changes, the model shown must, he said, be looked upon as merely a "flashlight" photograph of the atom, showing its state at some particular instant.

Suppose, he continued, that an electron moving with a speed of some 1,000 km. per second collided with this atom, the direction of motion being such that the "projectile" would, if undeflected, pass near the nucleus. Then, when this electron came close to one of the external electrons of the atom, the two would repel each other, since both were negative charges of electricity. The electron which constituted the "projectile" would thus be deflected into a new path, whilst that belonging to the atom would be displaced somewhat, but would in general return at once to its old position. If, however, the "projectile" were sufficiently swift and the collision took place under favourable conditions, the electron forming the target might be broken away from the atom to which it belonged and be driven off. When this happened the residue of the atom was said to be "ionised." It now carried one less negative electron than the positive charges in the nucleus, and this residue, therefore, appeared to be positively charged.

That this was the mechanism of ionisation was first shown by Townsend in 1900 in a series of experiments on the ionisation of gases by collisions. These experiments also showed the conditions necessary for the passage of a spark through the gas. The general character of the apparatus used by Townsend is represented in Fig. 6. Here an X-ray tube is shown sending a beam of X-rays through a mass of gas between the two plates indicated. The upper plate is positively, and the lower negatively charged, by connection to the terminals of a battery. The X-rays removed electrons from a number of the atoms encountered, and we thus had, in the space between the plates, a number of positively charged atoms and of free electrons. The latter were impelled by the electric field towards the upper plate, whilst the ionised atoms were attracted down to the negatively charged lower plate, and we thus got the equivalent of a current of electricity through the gas.

If the strength of this current were plotted against the voltage between the plates, the curve obtained had the characteristics shown in Fig. 7. At first the current increased proportionately to the voltage, but after a time it became constant, as shown by the horizontal portion of the curve. This indicated that the whole of the ions liberated by the X-rays were being removed from the gas as fast as they were formed. The strength of the current being measured by the number of ions reaching the plates per second was limited by the number of ions produced by the X-rays in the same time. Thus, as stated, the current became steady and independent of the voltage when the ions were removed from the gas as fast as they were formed. It was found, however, that if the voltage were very much increased, the current suddenly began to rise again, and at a very rapid rate, as indicated in the figure. What happened at this stage could be explained by considering the ideally simple case illustrated in Fig. 8, which represented two plates, A and B, one positively and the other negatively charged, the space between them being occupied by gas at a pressure of about 1/100 atmosphere. Suppose next that, by the action of, say, ultra violet light, an electron was liberated at A, and for simplicity assume that the gas, instead of occupying the whole 'tween space uniformly, was distributed in layers as indicated at C, D, E and F. Then, starting from A, the electron would move in free space till it met an atom in the first layer at C. With the strength of the field between the plates suitably adjusted, this electron would, at the moment of collision, have acquired just sufficient energy to dislodge an electron from this atom, losing its own kinetic energy in the process. Hence we should then have at C two stationary electrons and an ionised atom. The latter, represented by the section lined circles, would move to the left, whilst the two electrons, moving to the right, would both acquire sufficient energy in passing through the electric field for each to ionise an atom encountered at the second layer D. This process being repeated again and again, the number of ions (by which the current was conveyed) would increase in geometric ratio with the distance travelled. Hence it would be seen that if the process were started under suitable conditions the current would increase very rapidly with an increased voltage, as was indicated by the curve from L to M in Fig. 7. Up to a certain limit, Townsend's observa-

EXHIBITS AT THE BRITISH INDUSTRIES FAIR.

(*For Description, see Page* 263.)

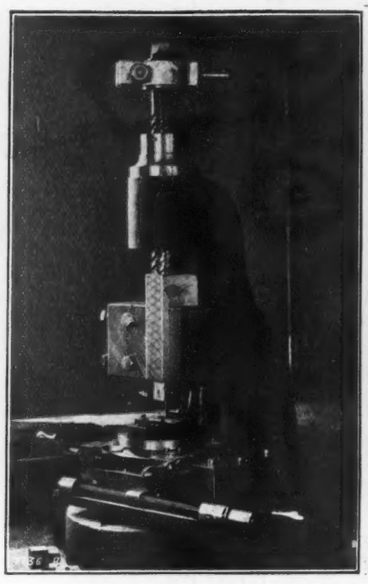


FIG. 27.

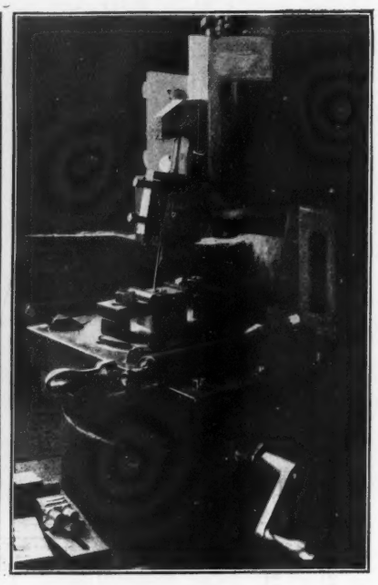


FIG. 28.

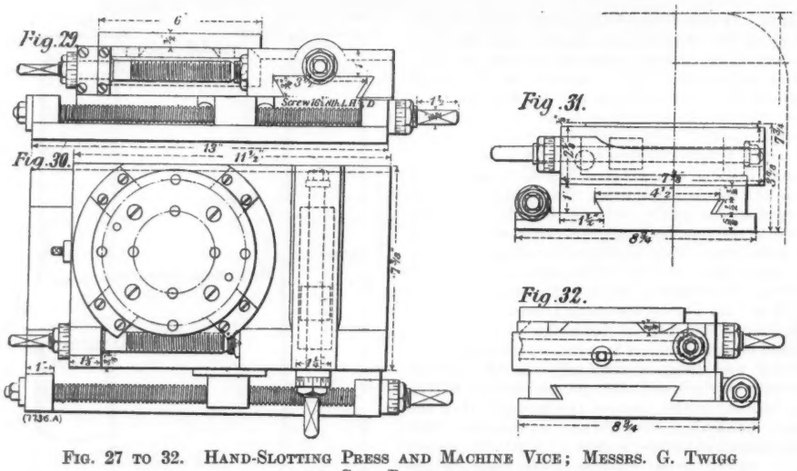


FIG. 27 TO 32. HAND-SLOTTING PRESS AND MACHINE VICE; MESSRS. G. TWIGG AND SON, BIRMINGHAM.

tions were very satisfactorily accounted for along this line of reasoning, but he found that with still higher voltages another break made its appearance in the graph, representing the relation of current to voltage. At a certain point the current began to increase still faster, as indicated by the break at M in Fig. 7.

The explanation was that when the voltage between the plates was sufficiently increased, the positive ions also acquired sufficient velocity between encounters with other molecules to be able to ionise them. The electrons, presenting a much smaller cross section than the atoms, escaped encounters in conditions which would lead to a collision between two equal atoms, and had therefore a free path four or five times as long as that of the positive ions; and it was during this free path that the field accelerated the ions.

Fig. 6.

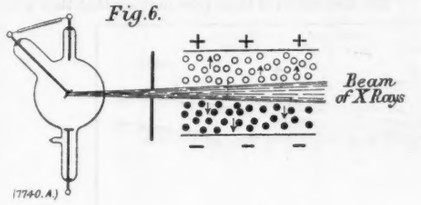


Fig. 8.

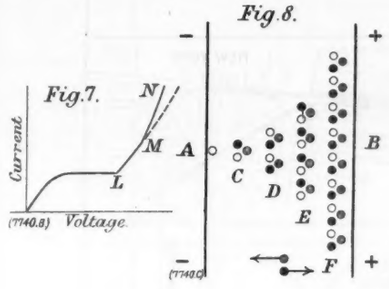


Fig. 7.

Fig. 9.

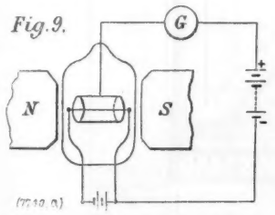


Fig. 10.

A mathematical discussion of the problem led to the following results :—

Let α = number of ions produced by electrons per cm.
β = number of ions produced by positive ions per cm.
n_0 = number of ions starting from negative electrode A.
n = number of ions reaching negative electrode B.

If only electrons were effective in producing ionisation we had $\frac{n}{n_0} = e^{\alpha l}$, where l denoted the distance between the two plates and α an experimental constant.

But if both positive and negative ions could cause further ionisation, then :—

$$\frac{n}{n_0} = \frac{(\alpha - \beta)\, e^{(\alpha - \beta)}}{\alpha - \beta\, e^{(\alpha - \beta)\, l}}$$

The condition necessary for the passage of a spark through the gas was $\frac{n}{n_0} = \infty$, which implied that l must have a value S given by the relation

$$S = \frac{1}{\alpha - \beta} \cdot \log_e \left(\frac{\alpha}{\beta}\right)$$

By determining from such curves as represented in Fig. 7 the values of α and β, Townsend was able to calculate the sparking distance between his two plates, and showed for the first time the conditions precedent to the passage of a spark. Whilst in a general way Townsend's explanation was satisfactory, it would be seen later on that it only represented part of the truth.

From experiments of the kind described, we could, the lecturer proceeded, form an approximate estimate of the speed which electrons must attain before they could knock an electron off an atom or molecule. Other estimates of this ionising potential had been made on the basis of experiments on the slow electrons with which thermionic currents were conveyed. One type of apparatus used is represented in Fig. 9. It consisted of a wire passing centrally through a metal cylinder, the whole being included in an exhausted space. As had been shown by Professor Richardson, if such a wire were heated, electrons were liberated from it in enormous quantities, and by making the cylinder positive and wire negative, a current could pass from one to the other sufficiently strong to be measured by a galvanometer. As was well known, such a device constituted an electric valve, since the current would only pass if the tube were positive relatively to the wire. The passage of the current could also be prevented by establishing a magnetic field across the axis of the tube, as indicated in the figure. The effect of this was to twist round the path of the electron, as indicated in Fig. 10, and by suitably adjusting matters the electron could be made just to skirt the surface of the tube, without touching it, and to return to the filament. Thus, at one moment there might be a strong current between filament and tube, and then, by a very slight adjustment, we would get practically none.

Fig. 11. GAS-FREE TUBE.

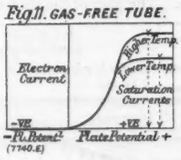


Fig. 12. TUBE CONTAINING GAS.

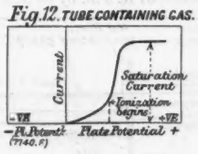


Fig. 13.

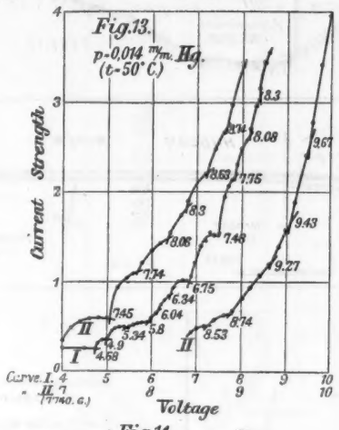
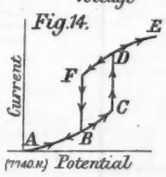


Fig. 14.



The magnitude of the current depended on the temperature of the filament. Taking the case of a gas-free tube, it was found that for a given filament temperature, the current between the tube and the filament at first increased with the potential difference between the two, but soon attained a "saturation" value, as indicated in Fig. 11. On then raising the temperature there was an increase of current, and a second higher saturation value was attained. This "saturation" arose, Professor Rutherford said, because the space between the tube and the filament was filled with electrons, the negative field due to which largely controlled the passage of the current.

If the tube were not gas free but contained, say, a little helium, argon or neon, a somewhat similar curve was obtained when the current was plotted against potential; but at a certain definite potential the current began to rise very sharply, as indicated in Fig. 12. This sharp rise was due to the ionisation of the gas, which began when the field was strong enough to give the electrons the necessary speed to produce ionisation by collision. In this way the ionising potential could be measured.

The measurement of this ionisation potential was of very great importance, because the production of light depended upon the return of an electron to an ionised atom, and there was a very important relation between the energy required to ionise an atom in the first instance, and the frequency of the light emitted, when an electron returned and neutralised the ionised atom. Denoting by E the energy which an electron must acquire before it removed an electron from an atom, and by ν the frequency of the light emitted on the return of an electron to the atom, we had the relation $E = h\nu$, where h denoted Planck's constant.

Different observers had at first found different values for the ionising potential, by which was meant the voltage through which an electron must fall freely in order to acquire sufficient energy to ionise particular atoms. It turned out that in some cases the effect of the collision was not to remove an electron entirely away from the atom, but merely to lift it to another orbit round the nucleus, in which it was momentarily stable, and where it remained for an instant of time, and then fell back into its original orbit. In doing this it emitted a "characteristic" radiation giving rise to a single spectral line.

The potentials which were sufficient to cause such displacements, though insufficient to ionise the atom, had been called resonance potentials, but the speaker preferred the term "excitation potentials." They had been studied by Franck by means of photo-electric effects. Some results obtained with mercury vapour are represented in Fig. 13, where current strengths are plotted against the accelerating voltages. Each little jump in the curves plotted, corresponds, not to the ionisation of the atom, but to the displacement of an electron from a normal to a temporary orbit, and these jumps are thus closely connected with the appearance of certain lines in the mercury spectrum. For measuring the speed of the slow electrons responsible for such displacements Hertz had adopted the following simple and ingenious method. He used a metal cylinder inside which was a second cylinder or "grid" of wire gauze. A potential difference of 0·1 volt was maintained between the two, and a hot wire filament external to the arrangement was employed to liberate electrons. Establishing a voltage between filament and cylinder, a current passed and could be measured. If, however, the electrons acting as projectiles, displaced, but did not remove, electrons in the atoms they encountered, the exciting electron would lose a corresponding amount of energy, and if brought to rest would have insufficient momentum left to overcome the $\frac{1}{10}$ volt P.D. between the gauze and the plate. Hence, no current would pass. In this way it was possible to get an idea of the value of these "excitation" potentials.

The atoms thus excited were not in a stable state. The displaced electron fell back into its old position, and in doing so gave out a characteristic radiation or pulse of light, which carried away with it the energy due to the falling in of the electron. When this unit of radiation met another atom it was capable of giving up its energy to an electron in the "target," displacing it, as before, to a temporary orbit. When this electron fell in, a new pulse of radiation was emitted, and the sequence of events described might be repeated again and again, the energy represented by the original displacement being handed on from atom to atom.

So far, Professor Rutherford proceeded, he had been concerned with the effects of the passage through a gas of not very strong currents. With very strong currents, however, it was found that atoms might be hit by more than one electron, and very complicated effects were then met with. At certain stages there might be more than one shift of the electrons attached to an atom. In this case the whole conditions for ionisation were altered, as part of the work necessary for complete ionisation was done when an electron was shifted to a fresh orbit, and hence cumulative effects became possible.

In such conditions, if current were plotted against potential we got curves such as are represented in Fig. 14. The current at first increased steadily from A to C, but on reaching C it jumped suddenly to D,

and in certain cases the jump implied a tenfold increase in the current, and with a further increase of potential it again increased steadily, as indicated along D E. On now reversing the process and diminishing the voltage, the original path was not retraced, but the current continued along the upper curve to F, when it fell suddenly to B. It was thus possible to get two different currents with the same voltage, a circumstance which was connected with cumulative ionisation.

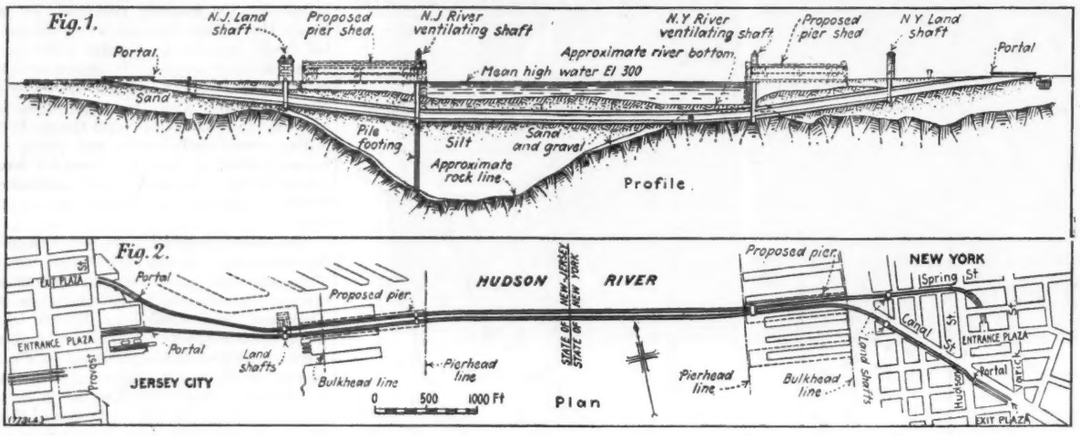
DRIVING 250-FT. PILES FOR THE HUDSON RIVER TUNNEL.

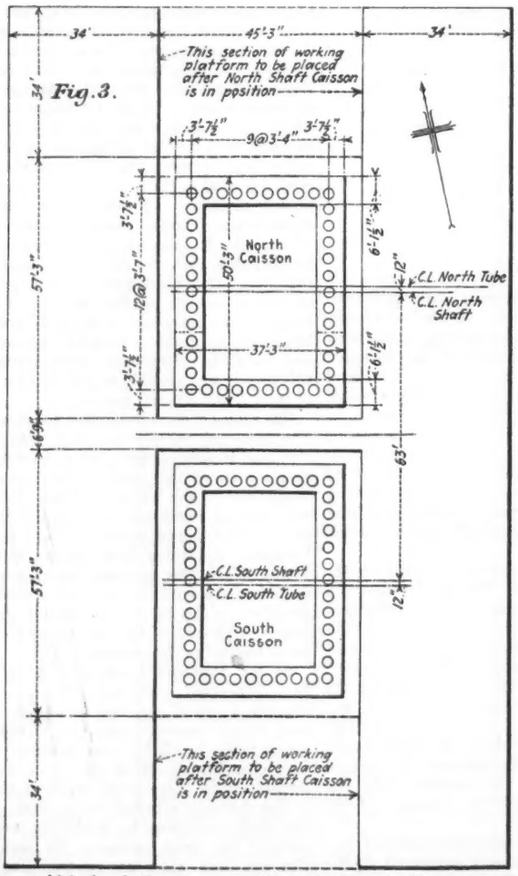
THE construction of the vehicular tunnel connecting New York and New Jersey under the Hudson River presented to the designers some unusual features. One of the problems which faced them was to obtain effective support for the ventilation shafts at the New Jersey end. At the point where it was arranged that these structures should be erected, the water is 30 ft. deep, and from the river-bed to the ledge rock there is an average depth of 220 ft. of silt. It was decided to build a pile footing for the support of each caisson on the ledge rock. The method of dealing with this foundation presents many interesting features, for the details of which we are indebted to an article appearing in our American contemporary, *Engineering News-Record*, for February 8.

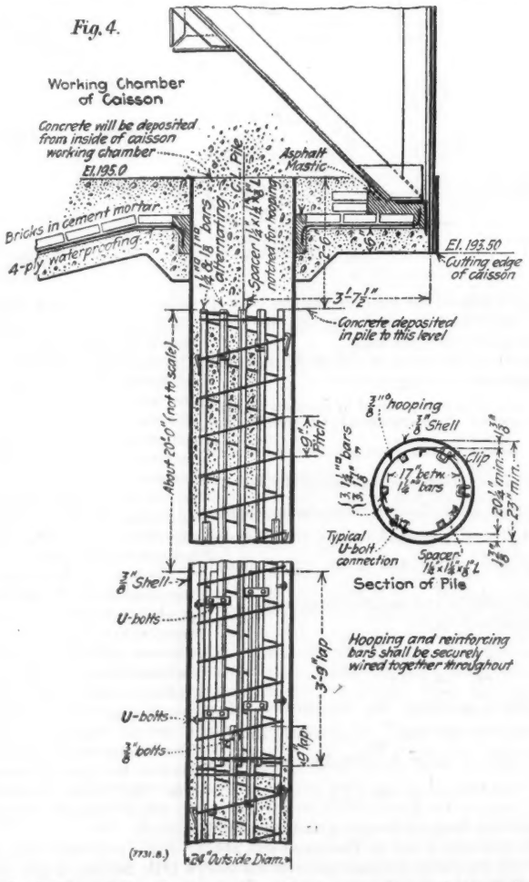
The general arrangement of the tunnel, which is being constructed to the designs and under the supervision of the New York and New Jersey Bridge and Tunnel Commissions, of which Mr. Clifford M. Holland is the chief engineer, is shown in Figs. 1 and 2. The position of the two ventilation shafts on the New Jersey side, where the long piles were necessary, is at the end of the proposed pier. The tunnel tubes are to be driven through from land shafts and will pass through the river shafts, which will be finished first. Each of these ventilation shafts is to have a rectangular cross-section 37 ft. 3 in. by 50 ft. 3 in. The plan of the shafts is shown in Fig. 3, as well as the position of the piles used for their support. With the dimensions shown, the total weight of each shaft of 108 ft. 6 in. height, with the superstructure, fans and other plant, amounts to 10,155 tons, reduced by a buoyancy of 6,109 tons to a net value, which has to be supported, of 4,046 tons. This dead load amounts to 2·16 tons per square foot, and the wind load on the superstructure adds 30 per cent. to the stress on the leeward side.

The method of providing the necessary foundation for each shaft, one of which is now almost completed, consisted of building up 42 piles or columns of reinforced concrete, extending from the ledge rock to the base of the shaft. Each pile was made up of a steel pipe, 24 in. diameter, with a ⅜-in. thick wall, and filled in with concrete reinforced by hooped rods. The construction of the piles is illustrated in Fig. 4. The steel pipes were driven through to the rock, and after the water was extracted and the reinforcement and concrete introduced, they were cut off at a point more than 100 ft. below mean high water level and 70 ft. below the bed of the river. On the support provided the river shaft was built.

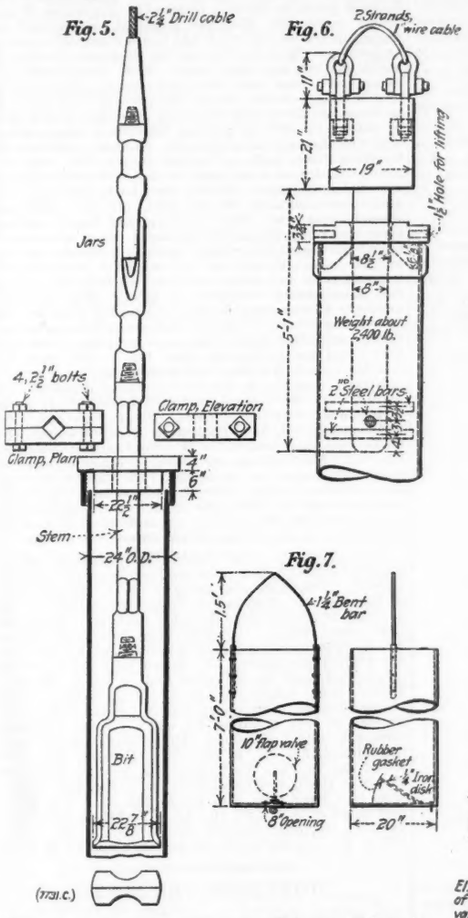
The dimensions of these piles indicate that they were not expected to act as columns, but a study was made of the resistance which would be offered by the silt to their bending, and the results showed that they might with safety, be considered on the basis of their sectional area for supporting a load without regard to their characteristics as columns.







The actual work presented many difficulties. The pipes had to be driven the full 250 ft., and during the operation had to be held plumb. The reinforcement had to be inserted and the concrete introduced until the requisite level was reached, when the excess length of pipe had to be cut off and removed. Early experiments in depositing the concrete under water were not successful, and consequently the water had to be removed. The operations were conducted from a platform about 6 ft. above mean high water. Each unit of the pipe used was 20 ft. long, and at the start



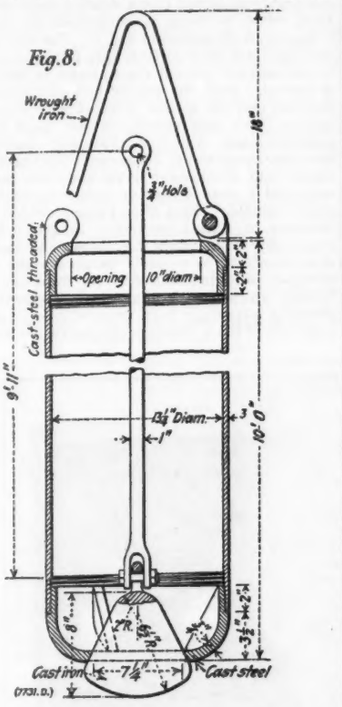
three of these lengths were assembled and held by a derrick in a vertical position. After passing this group down through the water to the bed of the river there was a projecting length of about 24 ft. above the platform. The pipe was clamped to two 12-in. by 12-in. battens, which were used to adjust it while it was being set plumb. After that operation, the battens were fastened to the deck to serve as guides during the sinking of the pipe. As each length of 20 ft. was coupled up, these operations were repeated.

The process used in well-drilling was adopted in the work, and a heavy cutting bit or "spud," was introduced through the pipe for the purpose of opening the ground for the driving of the pipe. From time to time the drilling operations were discontinued in order to raise the loose material to the surface in a bailer. A drilling bit weighing 2,500 lb. (*see* Fig. 5) was found to be the most suitable for the work. To assist the sinking of a pipe, such as the one in this case, the common practice of bolting clamps to the drill and allowing them to strike upon a flange or disc over the top of the pipe, was not used. The danger of accidentally dropping tools down the pipe was recognised, and in consequence the drilling tools were removed altogether and the driving accomplished with a hammer (Fig. 6), weighing 2,400 lb., which covered the pipe end. A hole, 20 ft. long, was drilled and bailed out before another length of pipe was added. The first nine sections of pipe required little assistance in sinking, but the later ones required harder driving. The sinking of a 20-ft. length of pipe was accomplished in each shift of eight hours, the work being carried on continuously on the three-shift system.

After the material had been removed from the pipe, the interior was cleaned with a water-jet. A 3-in. wrought-iron pipe, fitted with an inverted funnel at the bottom, was used for the purpose. Water was forced through this by a Pulsometer pump. The water pipe was gradually lowered until it was within a foot of the bottom. The flow was then reversed, the water being sent through the large pipe and out through the small one. This stage in the washing was carried on until the funnel touched the rock, and for one hour after clear water was discharged. A mandrel was then lowered through the pipe to ensure freedom from all obstructions or deformations.

To remove the water, the bottom of the pipe was first sealed with a plug of special concrete. When this had been allowed to set for 10 days, the water was bailed out with a bucket, shown in Fig. 7, made of a 7-ft. length of 20-in. pipe with a flap valve at the foot.

Before any reinforcement was introduced, the pipe line was tested for deviation from the vertical. This was performed with the aid of a white disc 8-in. diameter, lowered at the end of a sash cord, immediately below an electric lamp. Measurements from the edge of the pipe to the supporting cord, when the disc was touching the wall of the pipe, gave the variations from the vertical. Four pipes were found to be more than 12 in. out of the vertical, the maximum deviation being 24 in. Thirty-six of the 42 pipes were only out by amounts ranging from nothing to 7 in.



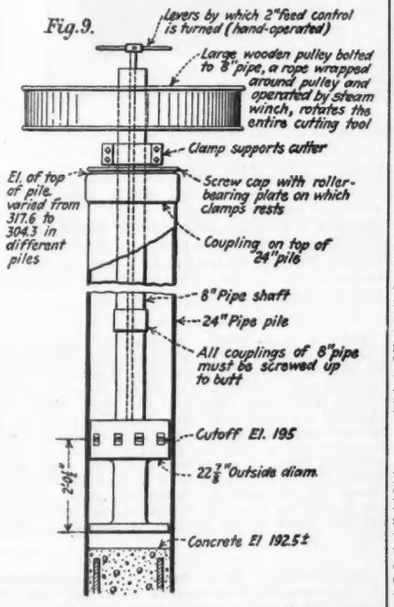


Fig. 9.
Levers by which 2" feed control is turned (hand-operated)
Large wooden pulley bolted to 8" pipe, a rope wrapped around pulley and operated by steam winch, rotates the entire cutting tool
Clamp supports cutter
El. of top of pile varied from 317.6 to 304.3 in different piles
Screw cap with roller-bearing plate on which clamps rests
Coupling on top of 24" pile
8" Pipe shaft
24" Pipe pile
All couplings of 8" pipe must be screwed up to butt
Cutoff El. 195
22⅞" Outside diam.
20'-0"
Concrete El 192.5±

The reinforcement was assembled into units about 20 ft. long. A clamp was designed for use in gripping the unit near its end, while the next was raised by a derrick, into position to be coupled to the first. A circular steel disc slightly smaller than the inside diameter of the pipe was suspended above the reinforcement to keep the rods in place. It was provided with hooks to engage with a ring clamped to the top of the reinforcement. When all was in place, the slackening of the derrick chains released the hooks, which fell to the middle and the gear was raised out of the pipe.

A depositing bucket, Fig. 8, of sufficient capacity to hold enough concrete to fill 3 ft. of the pipe, was designed, to introduce the 1 : 2 : 4 mixture used. The shape of the lower end and the design of the dumping gate, were made of the forms shown, to ensure that each time the bucket was lowered it penetrated into the surface of the previous deposit. The discharge below the existing surface reduced the formation of laitance.

A cutting head mounted on an 8-in. pipe and driven from a steam winch, the rope of which was wound round a heavy wooden pulley, was used to cut away the top part of the pipe. The arrangement is shown in Fig. 9. After the cutting, a wrought-iron cap was used to cover the top of the pipe and compressed air was passed into it. The upper part was then worked loose by one of the drilling machines and the pressure inside the pipe, and drawn out of place.

ROYAL METEOROLOGICAL SOCIETY.

THE usual monthly meeting of this Society was held on Wednesday, February 21, at 49 Cromwell-road, South Kensington, Dr. C. Chree, F.R.S., President, in the Chair.

Colonel E. Gold, D.S.O., F.R.S., introduced a discussion on a proposed "*Reform of the Calendar*," by Dr. C. F. Marvin, chief of the U.S. Weather Bureau. Dr. Marvin, in his pamphlet, states that the only modification of the Gregorian calendar, which really meets the need of the meteorologist is one which calendars the year in exactly 13 months of 28 days each, that is, a month of 4 weeks of 7 days each. The new year and, therefore, each of the 13 months would start on a Sunday. Some one day in each common year and an additional day in each leap year, should be set apart as public holidays, and not have any week-day name. The effect of the proposal on meteorological summaries is briefly discussed and the discontinuity between results based on old records, and those that may follow on the new plan is referred to.

The two following papers by Dr. S. Fujiwhara, of the Central Meteorological Observatory, Tokio were introduced by Mr. D. Brunt, M.A.: "*On the Growth and Decay of Vortical Systems.*" In this paper, Dr. Fujiwhara showed on experimental grounds that in water vortices of a like sense of rotation attract, and vortices of opposite sense of rotation repel each other. He traced the growth of vortices by amalgamation as a kind of animate growth, and adduced evidence to show that cyclones and anticyclones can be regarded as following similar laws. The equation of growth of energy of vortices was shown to be similar to the equation for vital growth given by Brailsford Robertson. The paper concluded with a discussion of vortical phenomena in astronomy and geodynamics. In the second paper, "*On the Mechanism of Extratropical Cyclones*," the equation for change with time of the vorticity of horizontal motion in the earth's atmosphere, devised by Hesselberg and Friedmann was discussed, and it was shown that the most important source of energy of a cyclone is to be found in the vorticity of the surrounding field. The feeding of a cyclone along the steering surface (of the Polar Front theory), was shown to be capable of explanation as the absorption by the main whirl of the horizontal whirl which forms at the surface.

OIL PUMPING.—Mr. G. W. E. Gibson, upon whose paper on "Oil Pumping" we commented on page 241 of last week's issue, draws our attention to a few points he wishes to correct, add or emphasise. We had stated that the late Mr. Suart had "fitted the pump of the Vindobala (Vindoba was an overlooked misprint) with an outside gear." But Mr. Suart, who was a shipowner, had only approved of the drawings which Mr. Gibson exhibited, and Mr. Gibson particularly wished to emphasise that there should be no loose valve seats with the solid gun-metal valve plates. The cargo duplex pumps of the San Fraterno were 22 in. by 14 in. by 18 in.; the 23½-in. by 8½-in. by 18-in. outside packed plunger pumps belonged to another plant. As regards the rotary pump (*vide* the last sentence of the fourth paragraph in the second column of the article), Mr. Gibson's actual words were: "The driving of such pumps by means of fluid rotors—as is done in the cheaper types—is to be deprecated." We had omitted the words between the two dashes. Finally, Mr. Gibson asks us to add that the heavy fuel oil mentioned (in the first column) in connection with the 10-ft. vertical and 50-ft. horizontal suction had a viscosity of 13,000 seconds. Redwood No. 1. The figure was not given in his paper; the Redwood standard for rape seed oil is 535.

MOTOR-STARTING PILLARS AND PANELS.

ALTHOUGH the mounting of motor-starting and control gear in protected pillars is naturally a somewhat more expensive arrangement than placing it on open panels, such pillars are coming into very extensive use. Their advantages are obvious. They are convenient and self-contained, protect the apparatus from mechanical damage or tampering, and at the same time have a neat appearance and assist in keeping the resistances and apparatus clean. These advantages are, however, sometimes purchased at the expense of considerable inaccessibility, and it is frequently necessary to dismantle completely the housing and probably break several connections to inspect the resistances or examine the back of the panel carrying the circuit-breakers, or other apparatus. In some cases the pillars are constructed with a door at the back in order to give access to the connections, but this arrangement is of little value for the frequent cases in which the pillar is standing against a shop wall, or column. In some other pillars headroom is necessary for dismantling, and this is not always available.

To meet these various objections, which may be raised to the ordinary type of pillar, the Igranic Electric Company, Limited, of Bedford, whose London office is at 147, Queen Victoria-street, E.C., has introduced the pillar which is illustrated in Figs. 2 to 5, on page 270. As is clearly shown in Fig. 2, the pillar is split vertically down each side, so that the front part may be let down when access is desired to the gear, or may be lifted clear as shown in Fig. 3. As will be evident from this latter figure and as is indeed obvious, this arrangement makes the front of the gear much easier to get at than does any arrangement with a door in the pillar. Accessibility is, however, carried further in the Igranic pillar, and the frame with the gear it carries is arranged to be swung forward as shown in Fig. 2. This movement can be carried out without breaking any electrical connections, and enables the back of the gear to be examined or adjusted. If more work is to be done on the gear than can conveniently be carried out with the panel swung forward in this way, it may be lifted bodily out of the pillar by disconnecting the cables at the bottom. This disconnection is the work of a few minutes only, and the panel with all its internal connections may then be removed to a bench or elsewhere and dealt with as desired without difficulty. The way in which the swinging panel is carried is clearly shown in Fig. 4. This figure also shows the catch by which it is held at the top end.

An isolating switch is a desirable fitting in a panel of this kind, although not an essential, and the pillar is designed to accommodate one, and is shown so fitted in our figures. The switch is carried in a lower chamber and is interlocked with the front portion of the case so that this cannot be opened until the isolating switch has been operated by the external handle. It cannot be closed again until the casing is replaced, so that the gear cannot accidentally be made alive while it is being worked on. This split housing has been made the standard for all Igranic "Conspede" and "Varispede" panels, and can be fitted in various ways. The "Conspede" panels contain a starter and an interlocked double-pole magnetically-operated circuit-breaker as illustrated in Figs. 2 and 3, while the "Varispede" panels include an interlocked field regulator in addition. The handle which operates the motor starter also controls the magnetically-operated circuit-breaker. At the beginning of its movement it closes an auxiliary contact which operates these breakers and, in the event of the breakers coming out, owing to overload or too rapid starting, it is necessary to bring the handle back to its initial position, so that all resistance is cut-in, before a new start can be made. The breakers cannot be closed unless all starting resistance is in circuit.

Although closed pillars of this type have much to recommend them, there is certainly a considerable market for a somewhat cheaper type of article and a completely-protected motor starting gear of the panel type, which is being manufactured by the Igranic Company, is illustrated in Fig. 6. The arrangement of this panel will be clear from this figure, and obviously it may be built without the ammeter or field regulator if desired. Both the starter and circuit-breaker are enclosed and the former is fitted with a low-voltage release. The chief novelty of the panel lies in the circuit-breaker, which is illustrated independently, to a larger scale in Fig. 1 annexed. This breaker is of a simple and inexpensive type and may usefully be employed in place of fuses on even comparatively small motor circuits. Fuses often cause considerable inconvenience in workshops owing to the delay which necessarily arises when they blow. As the cause of shut-down may be a purely temporary and accidental overload, on a machine tool for instance, a circuit-breaker which can be immediately replaced has considerable advantage over fuses which necessarily involve loss of time. The circuit-breaker, as will be seen, is enclosed in an iron case, which contains two front circular windows, through which indicators show when the breaker is open or closed. The breaker is operated by a front handle which is moved first in one direction and then in the other, to close the two poles in turn, and may be tripped by a press button in the centre of the handle. The breaker is connected so that the starter is dead when it is open.

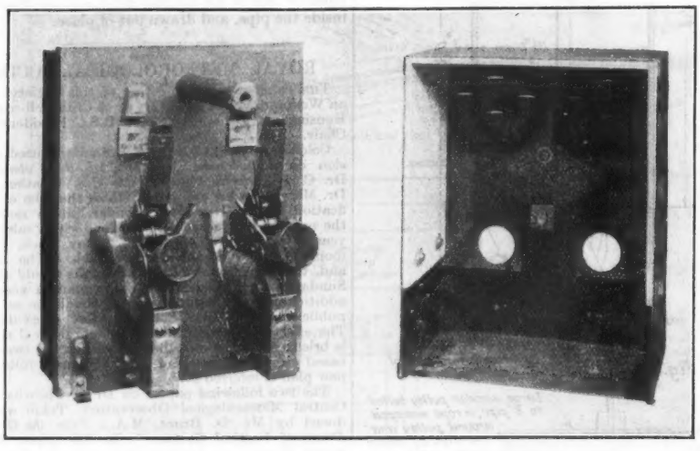


FIG. 1. ENCLOSED DOUBLE-POLE CIRCUIT-BREAKER.

BUENOS AIRES RURAL EXHIBITION.—The Argentine Consulate-General in London states that the Argentine Ministry of Agriculture will hold an Exhibition of wheat, corn-cleaning machines, &c., at the Rural Exhibition, Buenos Aires, from May 5 to 13. Seed, wheat, corn-cleaning machines, corn mills, kneading machines, and selected seed corn of all kinds will be shown, and manufacturers and growers are cordially invited to exhibit. Exhibits, both of machinery and seed corn, will be admitted into the Republic free of Customs duty and no charge will be made for exhibition space. Exhibitors not having an Agent in Argentina may consign their exhibits direct to the Ministry of Agriculture, Buenos Aires.

INTERNATIONAL AERO EXHIBITION, GOTHENBURG.—We have received from Admiral Mark Kerr, the chairman of the Advisory Committee in Great Britain of the International Aero Exhibition, which will be held at Gothenburg, Sweden, from July 20 to August 12 next, a communication in which particulars are given of the entries so far received from French, Italian, German and Czecho-Slovakian manufacturers. The French exhibit will apparently be particularly complete, entries of machines and accessories having been received from 14 different firms and organisations. Admiral Kerr expresses the view that unless British aircraft manufacturers take part in this important exhibition, a valuable opportunity for securing fresh trade openings in Northern Europe will be lost, and the aerial prestige of this country will suffer. The London address of the AdvisoryCommittee of the Exhibition is 16, Cumberland-terrace, N.W.1.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Taking the engineering and steel trades as a whole, recovery is progressing steadily, though by no means as evenly as could be desired. This district is benefitting considerably from the slump in Continental competition and the restriction of American competition, and for certain classes of steel and steel products there is a large volume of work to be done, if suitable prices can be arranged. The immediate danger is that raw and semi-finished materials will advance too rapidly in price to allow manufacturers of finished goods to book a reasonable proportion of the orders going, and that the potential revival will be nipped in the bud before it has had a reasonable chance to develop. There is a big call for all classes of common steels, pig-iron and steel scrap. More open-hearth furnaces have been put into commission. The current output is considerably above the pre-war level and will increase as plant erected during the war is put into operation. A difficult position has arisen in connection with the shortage of steel scrap. Recent purchases by Germany have made a big hole in reserves, with the result that furnaces are handicapped in finding sufficient material for charges. During the past month acid steel scrap has advanced 10*s.* to 11*5s.* per ton delivered, wrought-iron scrap, 90*s.* to 95*s.*; and heavy melting basic steel scrap, 80*s.* to 90*s.* delivered. Similar advances have been registered in light cast-iron scrap and borings and turnings. Though the full output of common steel is going away as quickly as it can be produced, there is still considerable weakness in special steels of high quality. Government stocks purchased during the war have not yet been exhausted, and are still being offered below production cost. For some purposes there is a better call for high-speed steel, but in the main the crucible branch is a long way from occupying a healthy position. Activity in the railway wagon department is finding work for sections producing lighter goods in the way of fittings and small tools. Messrs. Cammell Laird and Co., Limited, have booked an order for wagons and brake vans on behalf of the Kassala Railway Company, Limited. Shipbuilders are taking a larger tonnage of Sheffield's output of materials. The lighter sections are distinctly patchy. Stainless goods are still in wide demand both for home and export consumption, but departments devoted to the production of files, saws, pliers, pincers, &c., have not yet turned the corner.

South Yorkshire Coal Trade.—Blast-furnace coke is rapidly reaching a high price level owing to its continued scarcity. Deliveries are being made to inland users at 25*s.* per ton while export buyers are willing to pay as much as 35*s.* to 40*s.* A steady business is passing in best steam hards. Collieries keep free from stocks. The improvement has spread to cobbles, nuts and slacks, all of which are firmer. An active business is passing in gas coal, both for shipment and on home account. House coal merchants could comfortably handle bigger business in secondary grades, but are well booked forward in best qualities, for which recently-advanced rates are fully maintained. Quotations: Best branch handpicked, 32*s.* 6*d.* to 34*s.* 6*d.*; Barnsley best Silkstone, 28*s.* to 30*s.*; Derbyshire best brights, 25*s.* 6*d.* to 27*s.* 6*d.*; Derbyshire best house, 23*s.* to 24*s.* 6*d.*; Derbyshire best large nuts, 20*s.* 6*d.* to 22*s.* 6*d.*; Derbyshire best small nuts, 15*s.* to 16*s.* 6*d.*; Yorkshire hards, 21*s.* to 22*s.*; Derbyshire hards, 20*s.* to 21*s.*; rough slacks, 10*s.* to 12*s.*; nutty slacks, 8*s.* to 10*s.*; smalls, 3*s.* to 5*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The condition of things in the Scottish steel trade shows no change over the week. The amount of work already booked is fairly considerable, and the plant now in operation will be kept going steadily for a bit, but the future is a trifle uncertain. Buyers continue to hold back all but their most important orders for plates and sectional material, &c. Ruling prices are firm, but are practically unchanged. The black steel sheet makers are fairly well off for work both on the lighter and heavier gauges, as quite a number of orders for the latter were fixed up recently. The export trade overall shows some expansion, and foreign buyers are again more inclined to book supplies for early delivery. The current quotations are as follow: Boiler plates, 12*l.* per ton; ship plates, 9*l.* 5*s.* per ton; sections, 9*l.* per ton; and sheets, 11*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—In the West of Scotland malleable iron trade there is a little doubt as to the future course of events, but there is nevertheless a fair amount of activity at the various works. Home buyers have been placing a fair number of orders recently, and the export demand has also improved to some extent. Prices are steady, with "crown" bars at 11*l.* per ton delivered Glasgow. Re-rolled steel bars are in good demand.

Shipments of Scottish Pig-Iron.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, February 24, amounted to 1,870 tons. Of that amount 1,815 tons went foreign and 55 tons coastwise. The figures for the corresponding week last year were 383 tons foreign and 64 tons coastwise.

Scottish Pig-Iron Trade.—There has been no falling-off in the demand for Scottish pig-iron, and the output from the furnaces in blast is going away rapidly. The home consumers of hematite are taking up all that is being turned out, and as soon as general conditions get better the production will require to be increased. The demand for foundry sorts is good, both on home and export account, but in all classes of iron the cost of production

is mounting up and quotations are rising accordingly. The following may be taken as to-day's quotations, but some sellers are demanding a trifle more: Hematite, 5*l.* 17*s.* 6*d.* per ton delivered at the steel works; foundry iron, No. 1, 6*l.* per ton, and No. 3, 5*l.* 15*s.* per ton, on trucks at makers' yards.

Scottish Shipbuilding.—The shipbuilding returns for the past month do not show a great amount of activity in the yards and compare poorly with recent years. The output from the different districts was as follows :—

	Vessels.	Tons.
The Clyde	5	18,846
The Forth	3	2,050
The Dee and Moray Firth ...	1	100
Total	9	20,996
Total for year to date ...	15	37,381

The figures for the first two months of last year were 23 vessels of 83,972 tons, and for the year 1921 they were 42 vessels of 107,562 tons—this latter being a record. The Clyde output for the two months was 9 vessels of 34,541 tons, as against 32 vessels of 93,431 tons for the same period of 1921. Orders now on hand make up quite a respectable tonnage, but work has not yet been commenced on many of these new vessels. The advance in the costs of construction is now being looked upon as rather serious and likely to militate against much in the way of fresh business. Inquiries are, nevertheless, fairly numerous, but it is doubtful if owners will fix up until costs become easier. The P. and O. Steam Navigation Company are in the market for four new vessels of about 18,000 tons each, and several other good contracts are meantime hanging fire.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Recently it was mutually agreed by the coal owners and workmen that the wages in March and April should be determined by the audit for November and December. This alteration was brought about in order to mitigate the incidence on the general wage rate of the diminished output in the last week of December and the first week in January, resultant from the customary holidays. The first audit under this new agreement shows that the general wage rate in South Wales will remain at the minimum of 28 per cent. above the 1915 standard. The audit gave a surplus profit sufficient to pay only 13·73 per cent. on the standard compared with 16·06 in January and February. In order to pay the minimum the owners have to sacrifice 471,786*l.* of their standard profits, which brings the total amount sacrificed to 3,338,400*l.* since November, 1921. As the November figures have been published it is possible to calculate the results of the December audits, and it is shown that the surplus in December was 96,280*l.*, and that the owners were compelled to sacrifice 280,786*l.* in payment of the minimum wage. The surplus in November and December amounted to 313,267*l.*, the revenue of the industry suffering from the Christmas holidays and consequent absenteeism from work. Compared with November, the December output showed a reduction of 400,000 tons, and this loss not only reduced the proceeds, but also increased the cost per ton. The combined effect of the holidays was to raise the cost of production from 17*s.* 8*d.* to 18*s.* 1*d.* per ton, and to reduce the average pit-head price from 18*s.* 5*d.* to 18*s.* 4*d.*, thus yielding a profit of about 3*d.* per ton compared with an average profit of 9½*d.* per ton in the preceding four months. In the latter part of 1922 the average profit amounted to only 5*d.* per ton, and while 26,678,000*l.* were distributed in wages only 1,044,000*l.* represented profits. Thus the wages cost amounted to 11*s.* 4*d.* per ton and the profits retained by the owners to less than 5*d.* In December the average working week in South Wales was 5·78 days, compared with 5·68 days in November, while the earnings per shift per person were 9*s.* 7*d.*, 10*d.*, or 1½*d.* higher than in November. The total amount distributed in wages in November and December was 4,739,345*l.*, compared with 3,200,000*l.* in the corresponding period of 1913, an increase of 1,539,000*l.* for producing practically the same quantity of coal. During this last week coal prices have risen considerably on the Cardiff market. The prices now ruling are the highest reached this year, and show a tendency towards further improvement. This upward movement has been caused by a considerable demand for nearly all classes of coal from the Continental countries, particularly France and Germany. The Germans are estimated to have bought 250,000 tons for shipment over the next couple of months, while the French railways have also placed a number of orders. Prices are at present on the basis of 32*s.* 6*d.* for large and 25*s.* for smalls.

Cardiff Shipowners.—At the annual meeting of the Cardiff and Bristol Channel Shipowners' Association, held to-day, Mr. W. E. Hende, of the Portfield Steamship Company, Limited, was unanimously elected chairman, in succession to Mr. Frederick Jones, of the Abbey Line, Limited, and Mr. W. T. Gould, of Gould Steamships and Industrials, Limited, vice-chairman of the association for the ensuing year.

MARINE AUXILIARY MACHINERY.—At a meeting of the Institute of Marine Engineers, on Tuesday, February 27, Engineer-Commander R. Beeman read a paper on "Auxiliary Machinery for Marine Purposes," in which he reviewed the types of the various items of a ship's auxiliary equipment and referred to the scope for improvement of fuel economy in each.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, March 2, at 7.30 p.m., at 39, Victoria-street. Lecturette, "Glass-Forming Machines," by Mr. C. Saxton, Member. Friday, March 9, at 7.30 p.m. Ordinary meeting. Paper on "Rolling-Mill Machinery," by R. C. D. Fell.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, March 2, at Bolbec Hall, Newcastle-upon-Tyne. "Measured Mile Trials," by Mr. G. S. Baker.

THE INSTITUTION OF BRITISH FOUNDRYMEN, LANCASHIRE BRANCH.—Saturday, March 3, at 4 p.m., at the College of Technology, Manchester. Lecture on "Patternmaking, with Special Reference to Scroll Cutting," by Mr. H. Stead.

THE BRADFORD ENGINEERING SOCIETY.—Monday, March 5, at 7.30 p.m., in the Hall of the Bradford Technical College. Lecture on "Recent Developments in Connection with Waste Heat Recovery for Steam-Raising Purposes," by Major W. Gregson (late R.E.), B.Sc., Assoc.M.Inst.C.E.

THE ROYAL SOCIETY OF ARTS.—Monday, March 5, at 8 p.m., at John-street, Adelphi, W.C. 2. Cantor Lecture, "Accurate Length Measurement," by Mr. J. E. Sears, Junior, C.B.E., M.A., M.I.Mech.E. (Lecture I.) Tuesday, March 6, at 4.30 p.m.: "The Dominion and Colonial Sections of the British Empire Exhibition, 1924," by Major E. A. Belcher, C.B.E. Wednesday, March 7, at 8 p.m.: Ordinary Meeting, "The Forests of North Russia and Their Economic Importance," by Professor E. P. Stebbing, M.A., F.L.S.

THE INSTITUTION OF RUBBER INDUSTRY.—Monday, March 5, at 7.30 p.m., at the Engineers' Club, Coventry-street, W. 1. "Telegraph Cable Manufacture, Rubber and Gutta Percha," by Mr. H. Savage, M.I.E.E.

THE INSTITUTE OF TRANSPORT.—Monday, March 5, at 5.30 p.m., in the Lecture Theatre, Institution of Electrical Engineers, Victoria Embankment, W.C.2. Paper on "The Operation of a Railway-Owned Port," by Major G. S. Szlumper.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, March 6, at 6 p.m., at Great George-street, S.W.1. Ordinary meeting. Papers to be submitted for discussion: —"Some Problems Connected with the Rivers and Canals in India," by Mr. Joseph Melvill Lacey, M.Inst. C.E.; "An Irrigation Project of the Californias," by Mr. Sydney Lionel Rothery, Assoc.M.Inst.C.E.; "The Influence of Silt on the Velocity of Water Flowing in Open Channels," by Mr. Arthur Burton Buckley, Jun., O.B.E., Assoc.M.Inst.C.E.

THE INSTITUTION OF ELECTRICAL ENGINEERS. WIRELESS SECTION.—Wednesday, March 7, at 6 p.m., in the Lecture Theatre of the Institution, Victoria Embankment, W.C.2. "Development of Naval High Power Valves," by Mr. H. Morris-Airey, C.B.E.

THE INSTITUTION OF SANITARY ENGINEERS.—Wednesday, March 7, at 7.30 p.m., at Caxton Hall, Westminster, S.W.1. Paper on "The Mechanics of the Activated Sludge Process," by Mr. J. A. Coombs, A.M.I.Mech.E., A.M.I.S.E.

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS (INCORPORATED).—Wednesday, March 7, at 3 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C.2. Discussion on paper entitled "Rotary Interlocking Block," by Mr. A. B. Walls.

THE INSTITUTION OF BRITISH FOUNDRYMEN (LANCASHIRE BRANCH), BURNLEY SECTION. — Wednesday, March 7, at 7.15 p.m., in the Municipal College, Omerod-road, Burnley. Paper on "Some Foundry Problems," by Mr. W. H. Meadowcroft.

THE INSTITUTE OF METALS.—Wednesday and Thursday, March 7 and 8, at 10 a.m., in the House of the Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W.1. Annual General Meeting. Wednesday, March 7, at 10 a.m. Papers to be read and discussed: (1) "The Mechanical Properties of the Magnesium Alloys," by Mr. Leslie Aitchison, D.Met., B.Sc., F.I.C. (6) "Tests on Work-Hardened Aluminium Sheet," by Professor H. C. H. Carpenter, A.R.S.M., F.R.S., and Mr. C. Caldron Smith, A.R.S.M., D.I.C., M.Sc.; (5) "The Constitution of Some Alloys of Aluminium with Copper and Nickel," by Miss Kathleen E. Bingham, M.Sc., and J. L. Haughton, D.Sc.; (7) "The Recrystallisation of Cold-Worked Cadmium," by Mr. Maurice Cook, M.Sc.; (11) "Volume Changes Accompanying Solution, Chemical Combination, and Crystallisations in Amalgams," by Mr. Arthur W. Gray, B.A., Ph. D. Wednesday afternoon, at 2.30 p.m.: (20) "The Production and Heat-Treatment of Chill Castings in an Aluminium Alloy ('Y')," by Mr. W. Rosenhain, D.Sc., F.R.S., Mr. S. L. Archbutt, F.I.C., and Mr. S. A. E. Wells; (14) "The Modulus of Direct Elasticity of Cold-Drawn Metals as a Function of Annealing Temperature," by Professor F. C. Lea, O.B.E., D.Sc., Mr. V. A Collins, Ph.D., M.Sc., and Mr. E. A. F. Reeve, Ph.D., M.Sc.; (18) "The Structure of Eutectics," by Mr. A. M. Portevin; (9) "The Extrusion Defect in Brass Rods Extruded from a Multiple Die," by Mr. R. Genders, M.B.E., B.Met., F.I.C.; (3) "Further Studies in Season-Cracking and Its Prevention. The Removal of Internal Stress in 60:40 Brass," by Mr. S. Beckinsale, B.Sc., A.I.C. Wednesday, evening at 7 for 7.30 p.m.: Annual Dinner at the Trocadero Restaurant, Piccadilly Circus, W.1. Thursday, March 8, at 10 a.m.: (19) "Some Properties of the Copper-Rich Copper Aluminium Alloys" by Mr. R. C. Reader, M.Sc.; (2) "The Ternary System Copper-Aluminium-Nickel," by Mr. C. R. Austen, M.Sc., and Mr. A. J. Murphy, M.Sc.; (4) "The Inner Structure of the Crystal Grain as Revealed by Meteorites and Widmanstätten Figures," by Colonel N. T. Belaiew; (15) "The Hardness of Annealed Copper," by Mr. A. L. Norbury, M.Sc.; (16) "The Hardness of Certain Copper Alpha-Solid Solutions," by Mr. A. L. Norbury, M.Sc. Thursday afternoon, at 2.30 p.m.; (13) "The Density and the Hardness of the Cast Alloys of Copper with Tin," by Mr. Harold Heape, B.Sc.; (12) "The Heat-Treatment and Mechanical Properties of Alloys of Aluminium with Small Percentages of Copper," by Mr. D. Hanson, D.Sc., and Miss Marie L. V. Gayler, M.Sc.; (8) "The Constitution and Age-Hardening of the Ternary Alloys of Aluminium with Magnesium and Copper," by Miss Marie L. V. Gayler, M.Sc.; (10) "The Scleroscope Hardness Test. A New Form of Magnifier Hammer," by Mr. R. Genders, M.B.E., B.Met., F.I.C.; (17) "The Oxidation of Metals at High Temperatures," by Mr. N. B. Pilling, M.S., and Mr. R. E. Bedworth.

THE SCOTTISH ENGINEERS' ASSOCIATION.—Thursday, March 8, in the Hall of the Royal Philosophical Society, Glasgow. Mr. Robert B. Mitchell will deliver an address on the "Dalmarnock Power Station."

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—Friday, March 9, in the Connaught Rooms, Great Queen-street, W.C.2. Second Annual Costing Conference. The subject is "Standardisation in Costing."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, March 9, at 7 p.m., at Storey's Gate, S.W. 1. Informal Meeting. Discussion on "Aerial Ropeways," to be opened by Mr. W. A. Bowden, A.C.G.I., A.M.I.Mech.E.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, March 9, at 7 p.m., at the Engineers' Club, Coventry-street, W. 1. Annual Meeting. Presidential Address by Colonel Moore-Brabazon. At the conclusion of this the president will read a paper on "Aerial Photography," illustrated by lantern slides.

THE ROYAL INSTITUTION OF GREAT BRITAIN, FRIDAY, MARCH 9, AT 9 P.M.—The evening discourse will be delivered by Mr. C. W. Saleeby, M.D., F.R.S.E. The subject is "Sunlight and Disease." Afternoon lectures at 3 p.m. Tuesday, March 6: Sir Arthur E. Shipley, G.B.E., D.Sc., F.R.S., on "Life and its Rhythms; (II) Rhythm in Living Organism." Thursday, March 8: Theodore Stevens, B. Met., M.Inst.C.E., M.I.E.E., on "Water Power of the Empire (Lecture II)." Saturday, March 10: Sir Ernest Rutherford, LL.D., D.Sc., F.R.S., on "Atomic Projectiles and their Properties" (Lecture IV).

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is very little doing in Cleveland pig-iron, hardly any of that commodity being purchasable for early delivery. Most makers have fully disposed of their March-April output and are very disinclined to commit themselves further ahead. The consequence is that business is confined to transactions in parcels merchants are able to put on the market. No. 3 is now quite 117*s.* 6*d.* f.o.t., and in fact, 120*s.*, and even more has been paid. For f.o.b. delivery there is an extra charge of 3*s.* 10*d.* No. 4 foundry is 112*s.* 6*d.*; and No. 4 forge, 110*s.* Other qualities of Cleveland pig-iron are not on the market at all.

Hematite.—Demand for East Coast hematite is unabated, and trade would be on an extensive scale if more iron was available for disposal. Stocks have been practically disposed of, and so well sold are some makers that they have closed their books. Values are steadily advancing, but they are still quite low in comparison with rates ruling for Cleveland pig-iron. Sales of hematite mixed Nos. have this week been recorded at 112*s.* 6*d.*, and there are now keen buyers, both for home purposes and for shipment abroad at 115*s.* No. I. is at a premium of 1*s.*

Foreign Ore.—Consumers of foreign ore have considerable stocks and good contracts arranged, so that they are not in the market to buy at present. Whilst there is not much doing, however, sellers speak hopefully of the future and are inclined to take a firm stand. Up to 25*s.* 6*d.* c.i.f. Tees is asked for best rubio.

Blast-furnace Coke.—The position as regards blast-furnace coke is causing considerable anxiety to local consumers. Shortage is becoming more and more acute as the result of heavy buying of coke for export at phenomenal prices. Sellers are prepared to renew, so far as possible, contracts with regular customers, at about 38*s.* for medium Durham qualities, but there is very little to be had.

Manufactured Iron and Steel.—A marked upward tendency in finished iron and steel is no more than must be expected, seeing that in addition to increased and increasing cost of output, quotations for the products of this district have been lower than prices ruling in all other home markets. Producers have good orders booked, and though inquiries in some branches are rather less pressing than they have been, they continue on quite a considerable scale. Quotations for several descriptions have been advanced. Common iron bars are 11*l.*; steel billets (soft), 9*l.* 10*s.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 14*l.*; steel ship, bridge, and tank plates, 10*l.*; steel angles, 9*l.* 10*s.*; steel joists, 9*l.* 10*s.*; fish plates, 13*l.* 10*s.*; steel rails, 9*l.* 10*s.*; black sheets, 13*l.* 10*s.*; and galvanised corrugated sheets, 19*l.* 5*s.*

MOTOR-STARTING PILLAR AND PANEL.

CONSTRUCTED BY THE IGRANIC ELECTRIC COMPANY, LIMITED, ENGINEERS, BEDFORD.

(*For Description, see Page* 268.)

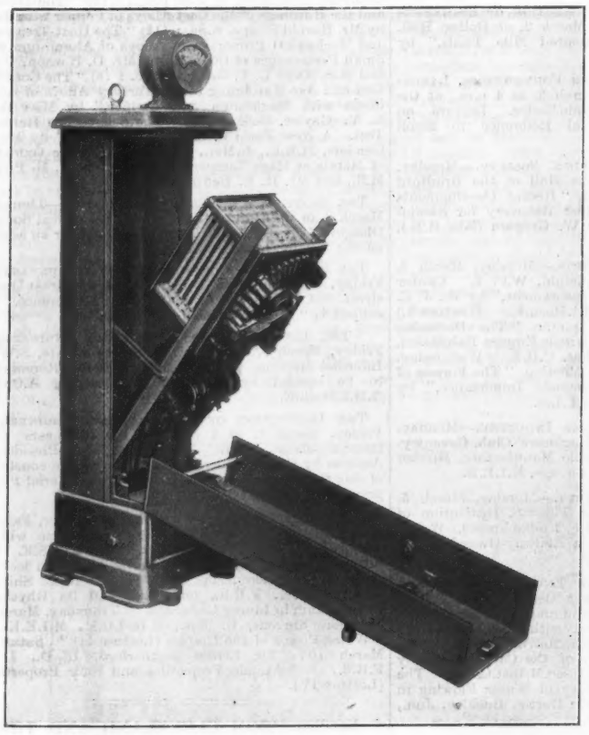


FIG. 2. PILLAR OPEN FOR INSPECTION.

FIG. 3. PILLAR WITH FRONT COVER REMOVED.

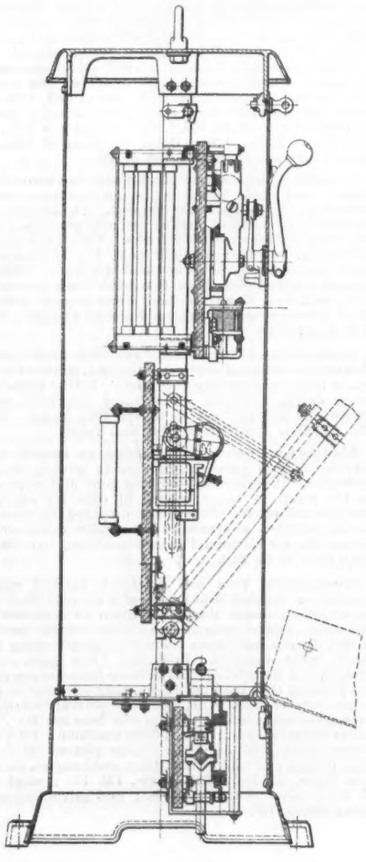


FIG. 4.

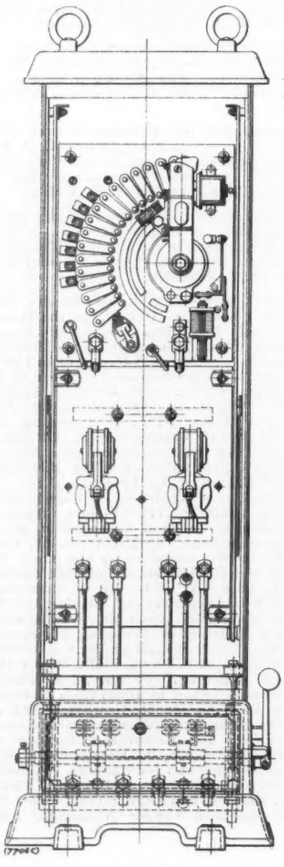


FIG. 5.

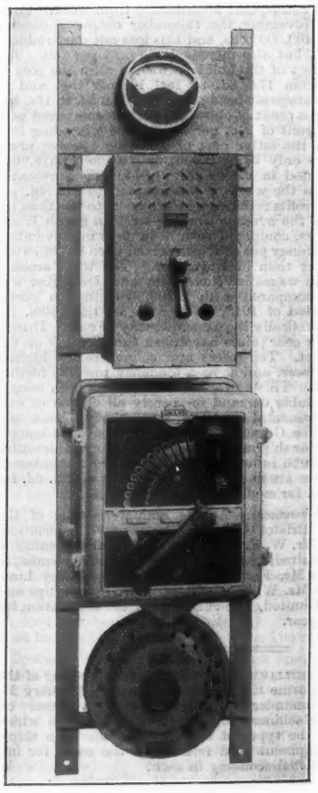


FIG. 6. MOTOR-STARTING AND CONTROL PANEL.

THE RESEARCH LABORATORIES OF THE GENERAL ELECTRIC CO., LTD.

(*For Description, see Page* 256.)

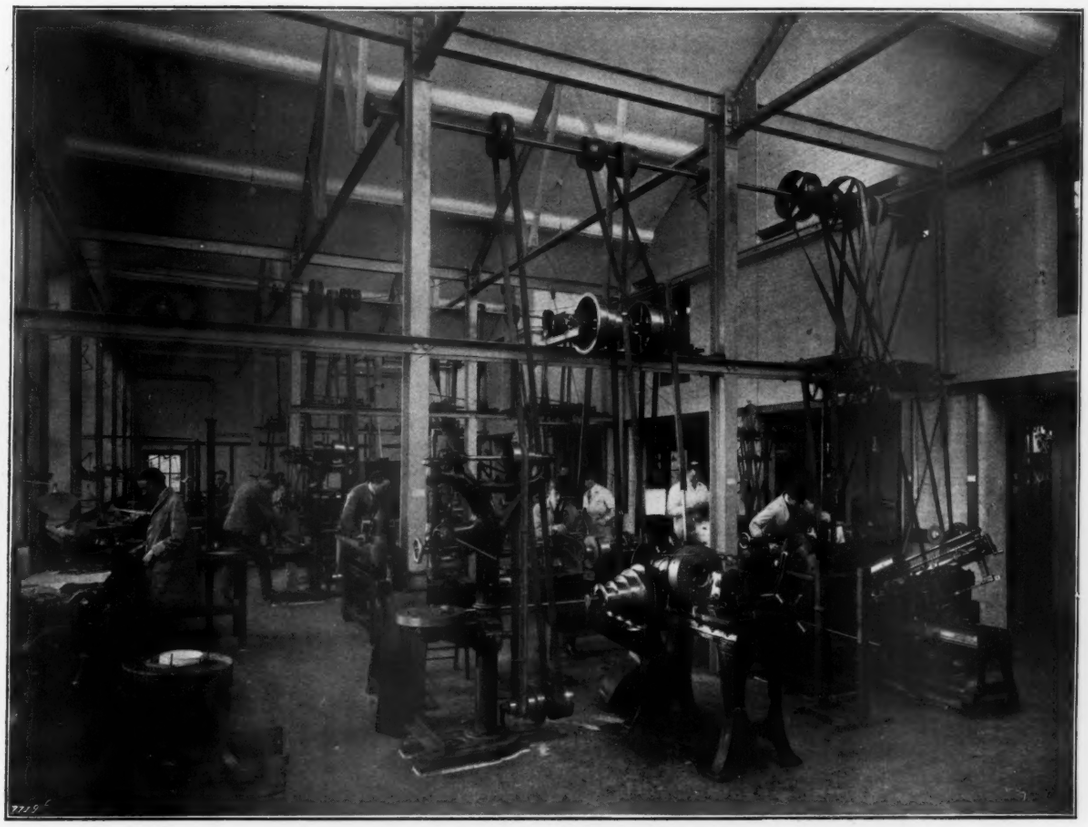


Fig. 4. The Metal-Working Shop.

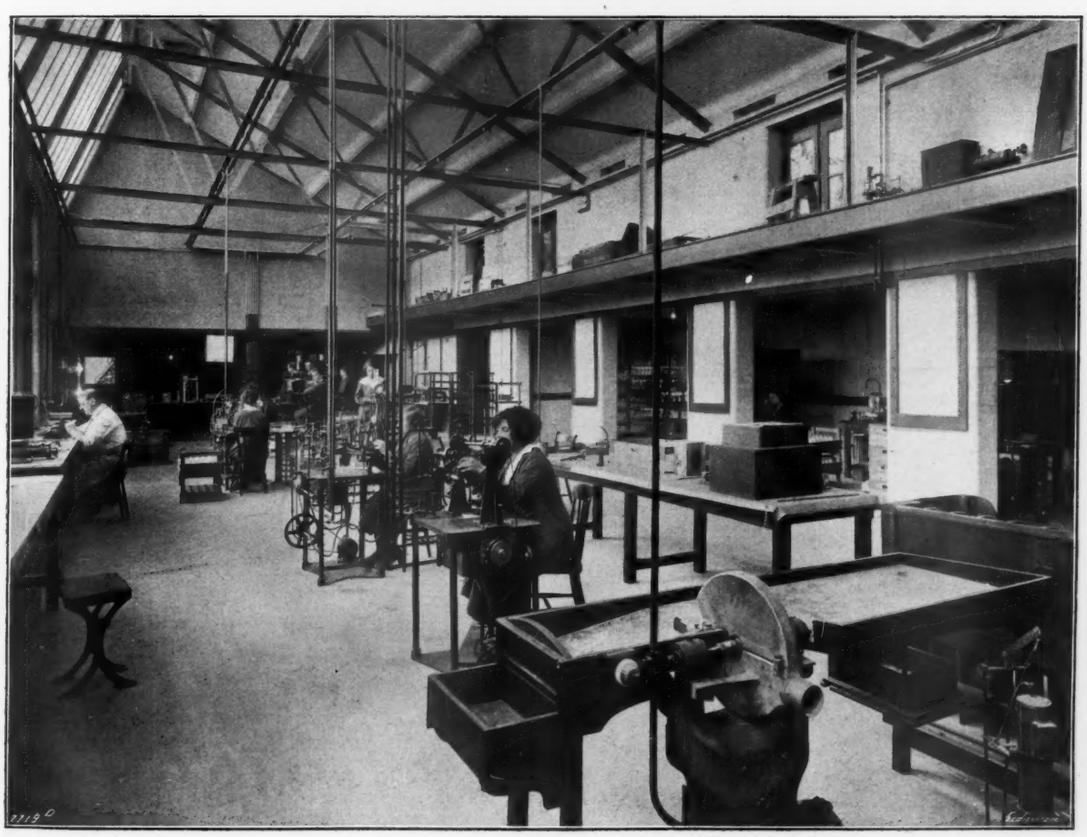


Fig. 5. The Experimental Lamp Factory.

(*To face Page* 256.)

THE RESEARCH LABORATORIES OF THE GENERAL ELECTRIC CO., LTD.

(*For Description, see Page* 256.)

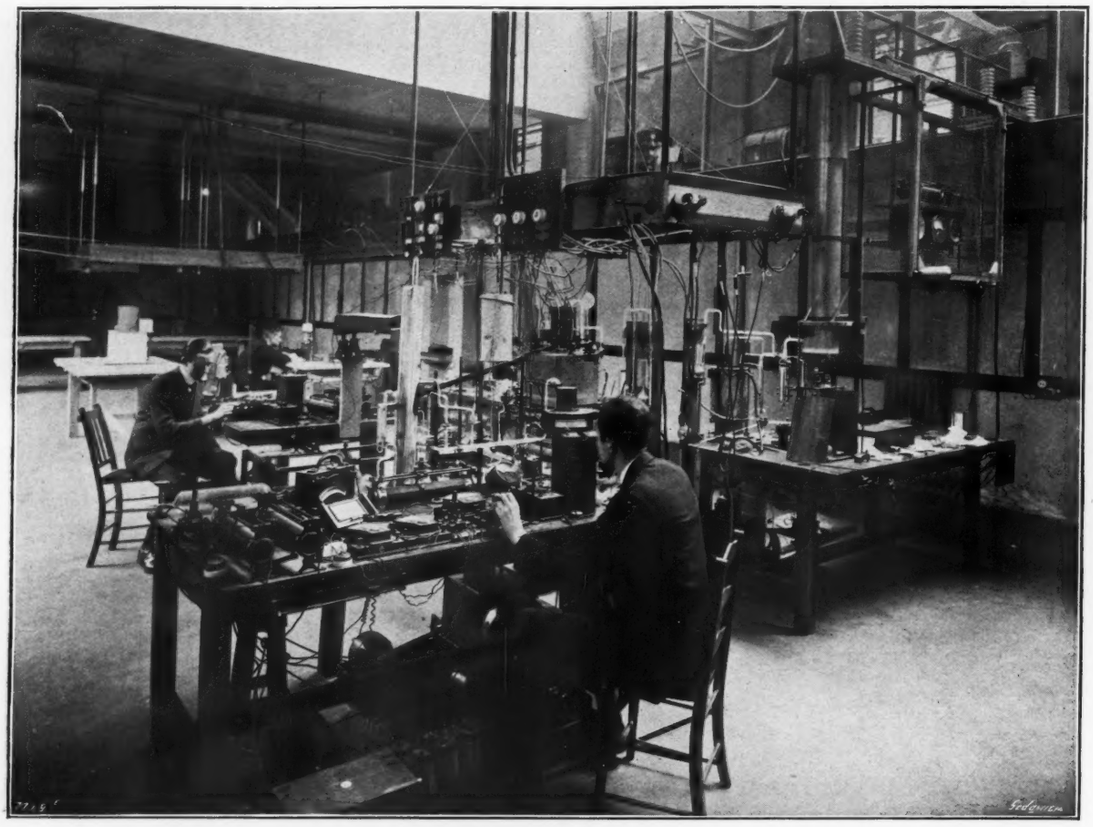


FIG. 6. THE VACUUM PHYSICS LABORATORY.

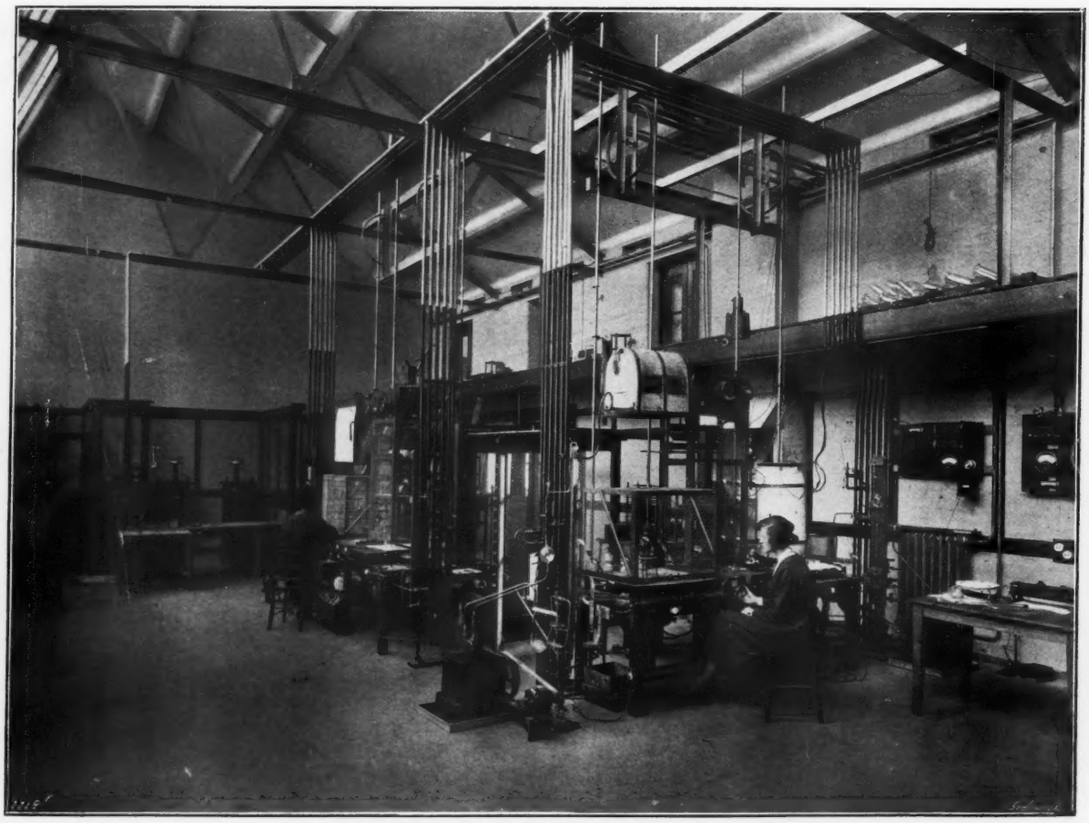


FIG. 7. THE EXPERIMENTAL VALVE FACTORY.

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(*For Description, see Page* 256.)

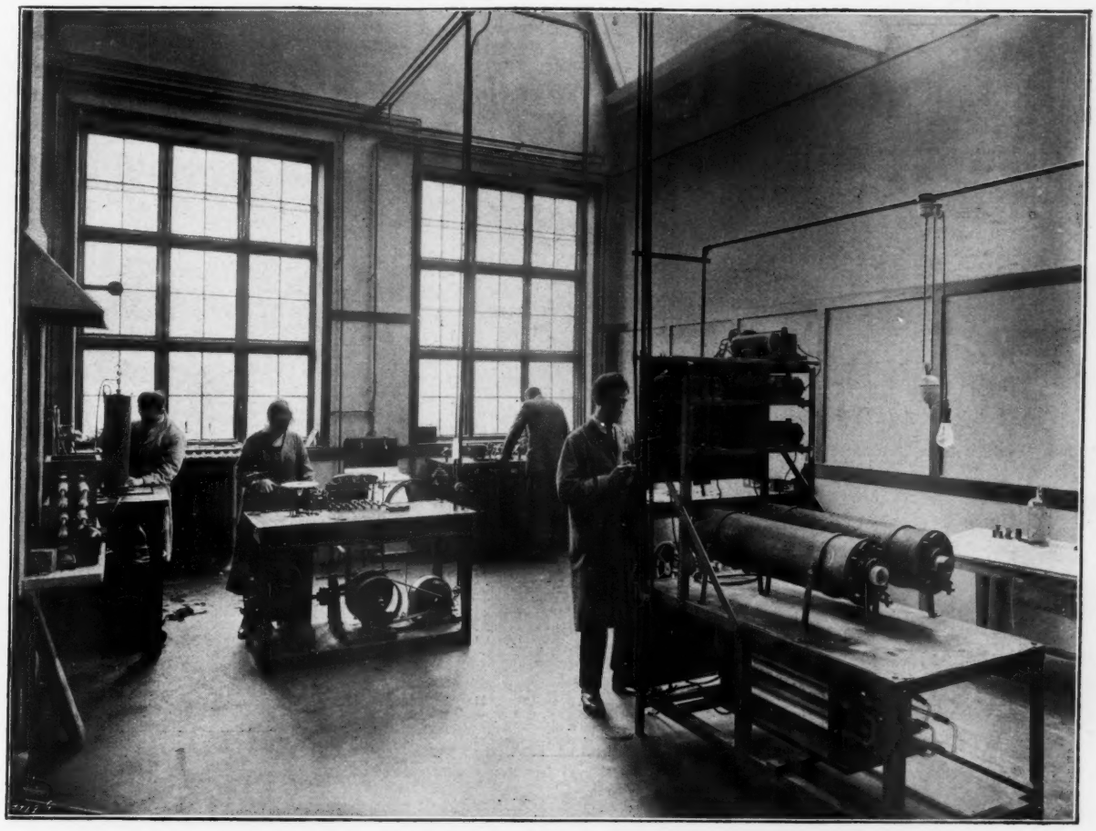

FIG. 8. THE EXPERIMENTAL TUNGSTEN WIRE FACTORY.

FIG. 9. LAMP LIFE-TESTING ROOM.

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FIGS. 10 AND 11. GALLERY SHOWING PIPE TRUNKS AND ELECTRIC CABLES.

FIG. 12. VIEW ALONG LOWER CORRIDOR SHOWING SWITCHBOARD.

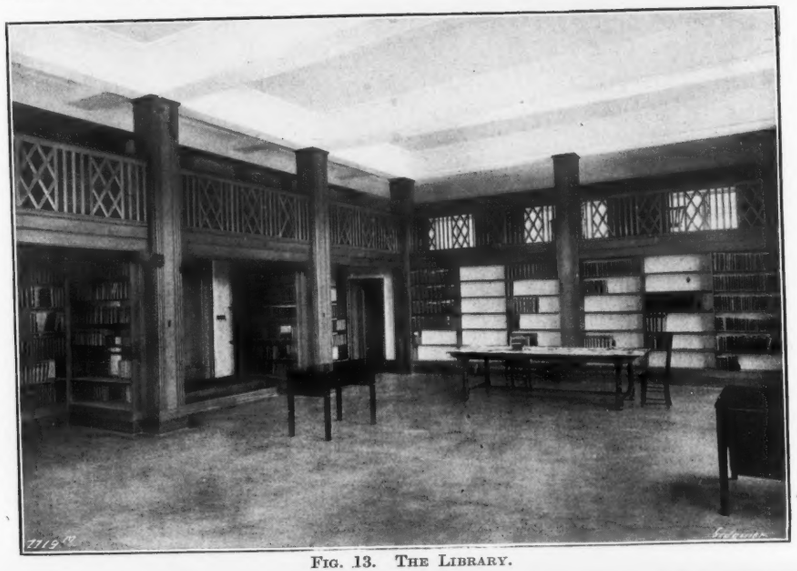

FIG. 13. THE LIBRARY.

(To face Page 257)

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Four One-Page Plates.—THE RESEARCH LABORATORIES OF THE GENERAL ELECTRIC COMPANY, LIMITED.

ENGINEERING.

FRIDAY, MARCH 2, 1923.

THE ENGINEER AND THE CHEMIST.

WHETHER engineering should be classified as a science or as an art has been a frequent subject of debate. The late Professor John Perry claimed for it the status of a science, but for our own part we have been inclined to regard it rather as the most scientific of the arts. The distinction between a science and an art seems to lie essentially in the circumstance that the knowledge of an art has to be acquired by personal observation and experience, whilst science being a generalisation and rationalisation of recorded experiences can be transferred readily from man to man. A vast mass of knowledge which mankind acquired at the outset with inordinate travail and an extravagant expenditure of time is summed up by science in a few leading laws and principles, a knowledge of which renders it unnecessary for the student to tax his memory with the details of the innumerable experiments and observations which have been made by the race. In no profession is greater use made of these scientific laws than in that of engineering, yet there remain large fields in which the engineer has to make good with very little aid from science. One instance often advanced is the high degree of perfection to which the reciprocating engine was brought, in spite of the large "time lag" of the science of thermodynamics. Steam engines were running successfully long before Joule had determined his equivalent, and subsequent to this many decades had to elapse before the development of thermodynamics had reached a point to be of much practical service in the drawing office. To-day the harbour or lighthouse engineer stands in a very similar position to that of the earlier constructors of steam engines. He has to proportion such structures as are exposed to the sea on the basis of his personal observations and experience, much no doubt as his predecessors at Tyre and Carthage did 2,500 years ago. On the other hand, the engineers who have given us wireless telephony found ready to hand and of immediate service the researches of Clerk Maxwell. Between these two limits engineers are able to make, in very varying degrees, use of the work of the physicist and chemist.

We put the chemist in the second place advisedly, since up to the present time the chemist has been of singularly little service to the engineer. He can seldom do more than tell the engineer whether the composition of the materials submitted to analysis is, or is not, up to standard. We emphasise this point because in the current number of *The Central* Professor Henry Armstrong, F.R.S., declares that no engineer should be allowed to work unaided or uncontrolled by the chemist. "Engineers," he says, "have no curiosity—the spirit of science is not in them, they are mostly at best skilful artificers." With respect to the charge of a lack of curiosity, there is every reason for believing that engineers as a whole are less open to this charge than any other large body of the community, but of course it remains true that it is only a small proportion of any community that really is curious about natural phenomena. The point is well put by Anthony Trollope, where in reply to a remark by Miss Dunstable to the effect that one doesn't puzzle over soap bubbles he makes, Lord Boanerges say: "Pardon me, Miss Dunstable, *one* does, but nine hundred and ninety-nine do not."

In view of the results of the inquiry made into the intelligence of the population by the United States Government, this state of affairs is hardly surprising, but those who take up engineering as a profession must certainly include a much higher percentage than the average, of men imbued with the "'satiable curiosity" which as Kipling records led the "Elephant's child" into temporary trouble, but to an ultimate gain. It is quite probable, we think, that as many engineers as chemists have attended the courses of lectures delivered at the Royal Institution by Sir J. J. Thomson or Sir Ernest Rutherford, and we would even venture to claim that they have understood them better.

Perhaps some light on the origin of Professor Armstrong's charge of "incuriousness" is to be found in his statement that the "Crystal Palace stands, whilst Charing Cross station, also a glass iron structure but much more modern, rusted and fell in years ago. Why does the Palace stand? It is for chemists to say, and they should be given the opportunity." As a matter of fact, corrosion played no part in the accident to the Charing Cross station roof, which was occasioned by a defective weld in a tie bar, which no chemist could have detected. Had the facts been as represented, there might have been some justice in asserting that engineers showed a lack of "curiosity" in not immediately starting an investigation into the resistance of the respective buildings to rust, but as matters stand no chemist could, speaking as a chemist, explain either why the tie bar at Charing Cross failed or why the Palace at Sydenham still stands. Nevertheless, though corrosion was in no way responsible for the fractured tie bar at Charing Cross, corrosion is undoubtedly of very serious concern to the engineers in charge of our steel and iron structures, and its prevention by means commercially practicable would be a gain of surpassing importance. This has, however, long been recognised, and as far back as 1840 an elaborate investigation into the chemistry of the corrosion of iron was organised by the British Association, and much similar work has been done since, in no small part with funds provided by engineers. So far, however, chemists do not seem to be agreed upon the intimate nature of the reactions involved. Even if they were so, but a first step would have been made towards reducing the loss by rust, which is the matter that interests engineers, as engineers. Apart from this, the elucidation of the process would appeal to them only in their non-professional capacity in the same way as does the determination of the dimensions of Betelgeuse. Indeed, many of the engineer's problems have been solved empirically long before scientific men were in a position to explain the *rationale* of the successful solution.

An interesting example of this is provided by the history of the purification of our water supplies. Here the credit for solving the problem appertains to the engineer in an overwhelming

FIG. 13. THE LIBRARY.
FIG. 12. VIEW ALONG LOWER CORRIDOR SHOWING SWITCHBOARD.
257)

degree, the bacteriologist stands second, and of the chemist, it is difficult to say more than that he, "also ran." In 1828 James Simpson constructed the first filter bed at Chelsea, and his example was subsequently followed by other engineers with the result that the London death rate by water-borne diseases was reduced far below that of Glasgow, although the London water was for the most part derived from polluted streams and that of Glasgow from a mountain lake. The most striking demonstration of the efficiency of the process was however afforded during the cholera epidemic at Hamburg in 1892. The intakes of the town of Altona were situated below some of the outlets from the Hamburg sewers, and the supply was thus highly polluted. Knowing this, the engineers responsible, passed the whole of the water through filter beds, with the result that whilst Hamburg, having no filter beds, was ravaged by cholera, there were none but imported cases in Altona.

How the filters effected the purification engineers were unable to say, but the chemists were in no better case, and indeed on the basis of their analyses were inclined to deny the efficacy of the process. It was not till 1881, that is to say, 53 years after the invention of the filter bed, that the first step was made towards elucidating its *modus operandi*. In that year the bacteriologist Koch invented the plate culture method of counting bacteria. With the new system of "analysis" thus provided, it became possible to determine the number of living and possibly dangerous organisms in the water before and after filtration, whilst the chemist by his methods could estimate merely the amount present of inherently harmless dissolved matter. The bacteriological study of water rendered possible by Koch's invention soon led to important changes in the working of the filters on which the chemist, following his own technique, had been able to throw no light.

Whilst Professor Armstrong demands that the chemist shall control the engineer it is interesting to note that he has but little good to say for the present methods of educating the chemist. Apparently, there is in operation here the same tendency which we have had occasion to deplore in the courses at our engineering schools and colleges, where early specialisation is becoming increasingly prevalent. In the old days a candidate for a Whitworth Scholarship had to know the elements of many branches of science, such as chemistry, metallurgy, optics, acoustics and electricity. To-day the tendency is more and more to confine the course to "directly useful" subjects, and we feel strongly that the change is far from being an improvement. We can also sympathise with Professor Armstrong in his denunciation of courses of "Re-search" which too often imply in engineering—as he says they do in chemistry—merely "repeating a search already [illegible] by some other fellow." In this matter of research, however, the engineer stands at a very serious disadvantage as compared with a chemist. The materials and apparatus required by the chemist are cheap for the most part, and what is dear belongs to the normal equipment of the laboratory. An engineering research, however, commonly involves very heavy expenditure. It would seem, for instance, a simple matter to determine the efficiency of a nozzle discharging a jet of steam, yet, as is well known, results were obtained in Germany which it was impossible to reconcile with practical experience. The experiments organised by the Institution of Mechanical Engineers have, we understand, cleared up the anomalies, but the cost has run into many hundreds of pounds.

Professor Armstrong, as is well known, is a very strong advocate of the heuristic method of teaching science, but we believe the policy a mistaken one. Probably it is less inept in chemistry, and particularly in organic chemistry, than in other branches of science. The organic chemist is mainly concerned with questions of structure, and so long as the compounds he studied were "two dimensional" he was able to go far without the aid of mathematics and showed in many cases really remarkable insight and imagination. When it became necessary to deal with compounds which could not be represented on the "flat" the difficulties increased, and mathematical knowledge became of greater importance. The engineer and the physicist have, however, to introduce still a further "dimension" in the shape of time, their problems being in the main dynamic rather than static, concerned with moving mechanisms rather than with structures merely. To deal adequately with the increased complication thus introduced, a sound grounding in mathematics is indispensable, but the ability to handle formulas brings with it certain dangers of its own. This has, in fact, been demonstrated even in chemistry, where, not long since, there was an influential school who proclaimed the futility and the probable baselessness of the atomic theory, declaring that they could deduce mathematically the results they required without the aid of this hypothesis. The school in question was, in short, content with the ability to compute results, rather than to understand them.

The same attitude of mind appears somewhat rife in the products of our engineering schools. The students too often learn to calculate, and having acquired facility in this, are indisposed to think. It is much commoner to find one who can calculate accurately the reaction exercised by a steam jet than to find one who can picture the mechanism by which this reaction is impressed on the nozzle box. The older school of engineers, less adept in mathematical methods, had to think mechanically and to form a mental picture of the distribution of the stresses and forces in which they were interested. To-day, a third year student with his slide rule would solve in a few minutes problems on which his predecessors possibly spent hours, but his knowledge is often somewhat superficial, and he is thus liable to go astray when confronted with problems, for which, as yet, formulæ supply no solution.

SUBSIDIES FOR CIVIL AVIATION.

THERE is little doubt that the development of civil aviation is a matter of considerable importance to the Empire both as a means of rapid transport and in connection with national defence. For this reason general approval was expressed of the principle of granting Government subsidies to the British aerial transport firms when the latter were threatened with extinction early in 1921 by the competition of the heavily subsidised French concerns. The immediate object of the subsidies was achieved and the services were continued, but their main purpose, we take it, was to encourage the development of civil aviation in order to render it self supporting at the earliest possible moment. Actually it must be admitted that although subsidies have now been paid for nearly two years, and in accordance with existing agreements are to be continued for another year, the development of civil aviation has been by no means as great as might have been expected; certainly the time when it is likely to be self supporting is not yet in sight. For this reason a committee was appointed by the Secretary of State for Air in January last to consider the working of the present subsidy scheme and to advise as to the method to be adopted in the future.

The committee's report has just been issued and their main proposal is to the effect that, on the termination of the present arrangements, at the end of March, 1924, a new commercial organisation, which is not to be an amalgamation of the existing companies, shall be established to carry on the aerial transport services. The new company, for which a capital of £1,000,000 is considered to be necessary, would be run on purely business lines, and would not be under Government control, except through one or two nominated directors. The committee consider that to bring such an organisation into being a subsidy of a stated total amount and extending over a period of 10 years should be guaranteed, since subsidies granted for the comparatively short periods of three or five years are not likely to induce private companies to risk their own resources for development purposes.

An essential condition to the present proposals is that the new company should have large resources of its own, so that in the expenditure of capital on operational experiments and on the development of new and extended routes, the financial risk should be mainly that of the company rather than that of the State. We have not sufficient space available to deal fully with the financial details of the scheme, but the proposal is that the subsidy should be of sufficient magnitude to enable a financial group to raise the share capital, and that the subsidy payment, which would be made annually but not in equal instalments, would aggregate not less than 1,000,000*l*. This, it may be remarked, would represent a smaller average annual payment than the present system, nder which it is estimated that about 512,000*l*. will have been spent during the three years ending March, 1924. In the event of war, the Government would reserve the right to take over all the new company's aircraft engines and plant, but the State would continue and possibly extend to the new company all the facilities now provided free to the existing companies.

It will be noted that the new proposals are not designed to include the element of competition as the earlier schemes were, but the committee are convinced that this feature will be sufficiently provided for by the direct competition of foreign concerns with large Government backing. In general, the proposals appear to be sound and likely to be effective if adopted; the long period over which the subsidy is to be extended is a particularly satisfactory feature. Even so it remains to be seen whether or not the necessary private capital will be forthcoming, although only 500,000*l*. of this would require to be subscribed at first. We are not quite clear as to how the three existing companies are to be treated under the new proposals, although the committee point out that their interests should not be overlooked. They are certainly, we think, entitled to special consideration in view of the pioneer work they have carried on in very difficult circumstances.

TRANSATLANTIC RADIOTELEPHONY.

SOME further particulars of the very interesting experiments on the possibility of commercial transatlantic radiotelephony now being carried out by the Western Electric Company were given in a lecture delivered to the Institution of Electrical Engineers on Thursday, the 22nd ultimo, by Dr. H. W. Nichols, of the company's department of physical research. It will be remembered that a successful demonstration of the system was given at the New Southgate works of the Western Electric Company in the early hours of Monday, January 15 last, and in our issue of January 19, on page 80, we referred to this demonstration and briefly explained the principles of the system. The matter is, however, of such importance that the additional information on the methods of transmission and reception employed, as explained in Dr. Nichols' lecture, will doubtless be welcomed.

The lecturer first pointed out that, in the simplest possible telephone circuit containing a battery, microphone and receiver, the current flowing in the line consisted of a uniform carrier current c, on which is superposed a variable current s having a frequency range, when ordinary speech is being transmitted, of from some 400 to 3,000 cycles per second. Since the magnetic flux in the receiver is proportional to the total current and the pull on the diaphragm is proportional to the square of the flux, the force is, therefore, proportional to $(c + s)^2 = c^2 + 2cs + s^2$. The only useful part of this force is that proportional to s, viz., $2cs$, and since s^2 is detrimental to good speech reception, it must be small, while $2cs$ is made as large as possible. The carrier current c is not directly useful, but serves to produce a base line at the receiving end about which the variable current s can grow and diminish without changing sign. A moment's consideration will show that, if the variable current oscillated on either side of the zero line of current as a base, the magnetic effect produced on the diaphragm would be of double the original frequency, since the diaphragm would experience a pull for each of the two halves of the wave above and below the zero; speech would obviously be unintelligible with such an arrangement.

With the simple circuit above referred to, however, if the characteristics of the line vary, both c and s will also vary, and the variation in the received signal would be twice as great as would otherwise be the case. To avoid this, transformers

are inserted in the circuit at the transmitting and receiving ends. These restrict the constant carrier current to the local transmitting circuit and only allow the variable current to pass through the line. At the receiving end, however, the effect of the variable current alone would be to produce oscillations in the diaphragm of twice the original frequency for the reason indicated above. It is therefore necessary to reintroduce the equivalent of a carrier current at the receiving end, and this is usually done, in land telephony, by employing a permanent magnet in the receiver. By this means the variable current produces changes in flux without altering the sign. This system has the advantage of effecting a considerable saving in battery power, since the losses in the line are due only to the small variable current, and also of reducing the effects of any variation in the characteristics of the line. From the above it should be clear that the carrier current does not convey any part of the message and that it is a disadvantage to transmit it.

The principles involved in the Western Electric Company's system of radiotelephony, which Dr. Nichols then proceeded to explain, are somewhat similar to those outlined above, and it is for that reason that we have dealt at some length with what may be familiar to many of our readers. The systems of radiotelephony usually employed are somewhat analogous to the simple system of land telephony described above, in which a carrier current is transmitted in the line. In radiotelephony, however, the place of the carrier current is taken by a carrier wave of uniform amplitude and of very high frequency; in the experiments of the Western Electric Company the wave length used was 5,000 metres, and the frequency would be 60,000 cycles per second. The carrier wave is modulated by the superposition on it of a wave having the form and frequency of the sound wave of the speech or music to be transmitted. The effect of modulation is to produce a wave of which the envelope has the same form as the modulating wave, and this form is repeated on both sides of the zero line; the lower half of the wave is, in fact, a reflected image of the upper half and *vice versa*.

It can be shown by harmonic analysis that, assuming for simplicity that a sound of a single frequency is being transmitted, a modulated wave of this character is made up of three component waves each of which is itself a wave of constant amplitude; there is a wave of carrier frequency, a wave of carrier frequency plus sound frequency, and a wave of carrier frequency minus sound frequency. Of these, the first mentioned is always of constant frequency and it contains no element of the sound to be transmitted, but the other two waves, or side waves, as they are called, vary in frequency according to the frequency of the particular sound wave affecting the transmitting microphone at any instant. For ordinary speech transmission, the frequency range of these side waves is about 3,000 cycles per second above and below the carrier wave frequency, so that the two waves occupy a band of frequencies with a total range of 6,000 cycles per second. Usually the complete wave containing the three components is radiated, but since the carrier wave conveys no part of the sound wave it can be omitted, and since the two side bands are symmetrical, it is only necessary to transmit one of them. This is actually done in the system of the Western Electric Company, the transmission being confined to one of the side bands only, and, as a result of this, we understood Dr. Nichols to state that, for any particular sound frequency, the power required for transmission over a given distance was reduced to one-sixth of that necessary for the transmission of the complete modulated wave.

The elimination of the carrier wave is effected by the circuit shown diagrammatically in Fig. 1. In this, the oscillations produced by the source are applied to the middle point of a differential transformer, the outer ends of which are connected to the grids of two thermionic valves. The plates of these valves are connected to the ends of a second differential transformer, the mid-point of which is connected to the valve filaments. It will be obvious that the oscillations will not be transmitted to the secondary of the last-mentioned differential transformer, since the two parts of the primary winding are balanced. When, however, a speech-modulated current flows in the transformer winding on the left of Fig. 1, the balance of the two oscillating circuits will be disturbed, and the effect of this will be to impress the two side bands on the secondary of the transformer on the right of Fig. 1. By a filtering device consisting of a combination of inductances and condensers, the side band of the higher frequency, *i.e.*, the one of the carrier-wave frequency plus the speech frequency, is subsequently eliminated, and the side band of lower frequency is radiated from the aerial. In the apparatus actually employed for the transatlantic transmission above referred to, a start is made by developing a completely modulated wave with a power of about 5 watts, from which the two side bands are separated out by the balanced circuits shown in Fig. 1. The subsequent elimination of one of the side bands reduces the power to 2 or 3 watts of single-side-band telephone current. This power is raised to 300 watts in a three-valve amplifier, while a second valve amplifier raises it to 5 kw., and two further valve amplifiers, used in parallel, are capable together of increasing the power to

Fig. 1.

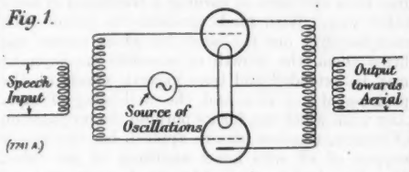
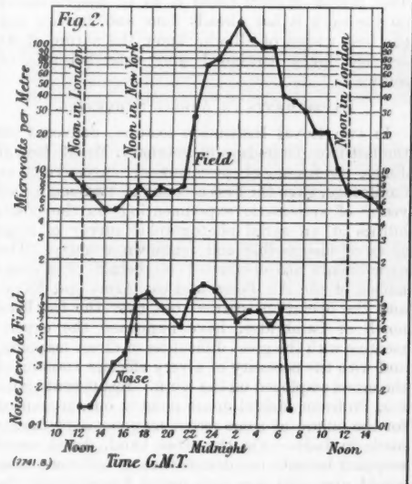


Fig. 2.



200 kw. From the last amplifiers the oscillating current is supplied to the aerial, but actually only 60 kw. was used in the experiments, since that power was sufficient for the purpose, being equivalent, Dr. Nichols stated, to 250 kw. of completely modulated wave.

At the receiving end, a wave of carrier frequency is re-introduced for a similar reason to that above referred to in connection with land line telephony, viz., that without it the speech frequencies would be doubled. This wave is supplied by means of a local oscillating circuit coupled to the receiving circuit, but otherwise the method of reception is very much the same as that in common use. The actual reception at the New Southgate works was carried out on a square frame aerial of 6 ft. sides and having 50 turns of wire. The middle point of the coil was earthed and the oscillating electromotive forces applied to the grid of the receiving valve from one-half of the coil only. The object of this arrangement was to increase the directional effect of the frame aerial by preventing the frame from acting partially as a vertical antenna, as it otherwise would do.

For transatlantic radiotelephony, the system described above has another important advantage which the lecturer proceeded to explain. The range of wave lengths available for transatlantic working, he pointed out, was from 8,000 metres upwards, the longest wave length likely to be employed being about 30,000 metres. The frequency of the former would be 37,500 cycles per second and of the latter 10,000 cycles, so that the available range of frequency would be 27,500 cycles per second. If the completely modulated wave with the carrier wave and two side bands, were transmitted the range of frequency utilised by one system would be 6,000 cycles per second, so that only four systems could be worked in the whole available frequency range. By omitting one of the side bands, however, the number of systems that could work simultaneously would be doubled; moreover, since about ten telegraphy systems could operate in the same frequency range as one telephony system, there would be plenty of room for them.

In our previous article we referred to the measurements of the relative strength of signals and of extraneous noises, made at the New Southgate works with the object of determining to what extent communication by radiotelephony would be possible throughout the year. Dr. Nichols dealt with this part of the subject in the concluding portion of his lecture, and also referred to some of the results obtained. To ensure intelligible speech it is essential for the strength of the signals received to be some 10 or 15 times that of the various extraneous noises. As long as this relationship is maintained, the absolute strength of the signals is of little importance, since they can be amplified to almost any desired extent. Amplification is, however, useless unless the signals are much stronger than the noises, since both would be amplified equally. To determine the power required at the transmitting end to ensure the necessary strength of signals at the receiving end, measurements of the strengths of signals and noises, we understand, will be continued daily for a year. When these have been completed it will be possible to decide whether transatlantic radiotelephony is a commercial proposition or not.

The measurements of signal strength are made with the frame aerial above described, the electrostatic field near the frame being determined while a signal is being received and compared with that obtained with a signal of known strength. In Fig. 2, annexed, the results of a typical day's measurements are plotted, the strengths of signals and noises being given in microvolts per metre on a time base; it should be noted, however, that the scale of ordinates is logarithmic, so that the strength of signals relatively to the strength of noises is much greater than might appear at first sight. From the diagram it will be seen that the signal strength from noon to 8 p.m. G.M.T. is about 7 or 8 microvolts per metre, rising rapidly at the latter time until a maximum of 130 microvolts per metre is reached at about 2 a.m; the strength then declines less rapidly until noon of the following day. The noise at noon is about 0·15 microvolt per metre, but this increases until about 6 p.m., and then remains fairly steady throughout the night in the neighbourhood of 1 microvolt per metre. For the particular day on which the measurements plotted in Fig. 2 were taken, communication would be possible for 14 hours out of the 24 with a power of 60 kw. employed at New York. Round about 6 p.m., however, reliable communication could not be maintained with this power, since the signal strength at this time has not sufficient preponderance over the noises. In the summer, the conditions are less favourable, since the noises increase in magnitude and the signal strength diminishes; the worst period of the year is July and August. By continuing the measurements throughout the year, however, it is expected that sufficient information will be obtained to enable a station for transatlantic radiotelephony to be designed and constructed if and when it is demanded.

NOTES.

THE IDEAL HOME EXHIBITION.

The seventh of the series of Ideal Home Exhibitions organised by the proprietors of the *Daily Mail* was opened at Olympia yesterday, and will remain open until March 24. Although most of the exhibits are naturally of domestic labour-saving devices, furniture, decorations, gardening and wireless telephony there are a number of items of interest to the engineering public. Plant for the mixing of concrete and bituminised or tarred

macadam are shown as part of the essential equipment for the erection of concrete houses, but they have a much more extensive field of service. Among these there is a mixer introduced by Messrs. Drummond Bros., Limited, of Guildford, in which there is ample protection from any dirt or grit for the gears which operate the revolving drum. A top cover over the gearing serves to deflect any falling matter clear of all the operating mechanism. The revolving drum is supported at the front on two rollers, mounted on roller bearings, and free to move to either side to accommodate any slight irregularity formed in the drum. The machine is designed to suit the drive from the firm's "Willing Worker" engine which was described in our columns recently (Vol. CXIV, page 707). Concrete mixers are also shown by Messrs. Winget, Limited, of Warwick, who display types of plant for concrete block moulding. There are few novel methods of building construction exhibited, but the application of existing systems to the erection of cottages and bungalows, in concrete, brick and rubble, timber and substitute preparations, is demonstrated by actual examples. Standard house lighting sets, either providing petrol-gas or electricity, small pumps for water raising, water softening installations, refrigerators and ice-making plants in sizes suitable for country houses are exhibited on many stands. The magnitude of the wireless telephone section and the introduction of wireless concerts in a hall seated for an audience of 1,000, give an indication of the development of that industry in this country.

Ship Registration Society Rules.

The annual meeting of the British Corporation for the Survey and Registry of Shipping was held in Glasgow on Wednesday, February 21, when the chairman, Mr. Robert Clark, reported the 1922 output of new tonnage as 210,000, compared with 281,000 the previous year, and the additional tonnage added to the Register in 1922 as 407,000, as against 533,000. The revision of the rules of the Corporation during the last year was referred to by Mr. Fred J. Stephen, the Chairman of the Technical Committee, as an expansion rather than a change in substance. Formerly special submissions had to be made of schemes in which longitudinal frames were supported by wide special transverses or with small cross frames supported by wide spaced longitudinals. Definite rules were decided on during the year regarding the scantlings of such vessels, and these are now available to the designers. Experience has satisfied the Technical Committee that there is a necessity to increase the minimum thickness of the strength-deck plating in such vessels as those in which the distribution of cargo or other weights has the effect of producing increased compression on the topsides. In the case of bulk-oil carriers the important change was made of adding 20 per cent. more area to the strength-deck plating of ships with the engines aft. The new rules for machinery provide more fully than they did for oil fuel installations, and the rules for shafts of internal combustion engines now embody a modification for flywheel effect. The committee do not yet feel justified in making the rules for that type of machinery absolute, and consequently they must still be regarded only as provisional. Among the new projects, the quest for propelling systems which give better results in service than reciprocating steam engine, has resulted in the fitting of Diesel-electric transmission and the installation of Scott-Still engines in vessels under construction. During recent months there has been evidence of a demand for the smaller sizes of ships, under 300 ft. length, and given reasonable conditions of trade and production there is every probability that the demand will continue.

Science in Industry and Commerce.

The British Science Guild was founded in 1905 by the late Sir Norman Lockyer, for the application of the methods of science to all branches of human endeavour, and thus to further the progress and increase the welfare of the Empire. This endeavour, ambitious but essentially practical and necessary, has, in the intervening years, been seriously hampered by lack of funds and the troubles due to the European War. Now that the necessity for every activity of this character has grown enormously, the Guild has started afresh its old campaign with renewed vigour. A meeting for the propagation of the aims of this valuable institution was held in the Mansion House, London, on Tuesday of this week, through the interest and appreciation of the Lord Mayor, who presided. Lord Askwith, the President of the Guild, before dealing with the purpose of the work of the institution, and moving a resolution referring to the necessity for the progressive use of scientific knowledge in industry and commerce, read a message from the King, in which His Majesty "welcomed the increased efforts to stimulate the scientific spirit and to secure that application of science to industry, commerce, and, indeed, to all fields of human activities as essential to efficiency and to the closer fellowship of all parts of the Empire." The advocacy of a provision of awards to those pioneer and constructive workers in fundamental scientific work, was the subject of a speech of Sir Robert Ross, who cited examples of workers in his own field who could find little work to do because of the difficulty of continuing their researches free from the cares of earning a livelihood in some other way. With funds available to permit such men to carry out the work for which nature has fitted them, the growth of scientific development may be extended and have gigantic effects on the progress of our race and the well-being of man. Any work which has for its purpose the propagation of science, whether pure or applied, has the hearty support of all who know anything of its value. The British Science Guild is to be congratulated on the work it has already done and, further, has the best wishes of all who know the nature of its activity, for a continued and extended field of service.

Experiments in Aerial Surveying.

In two Royal Institution lectures, delivered on the last two Thursdays in February, Mr. B. Melvill Jones, professor of aeronautical engineering at Cambridge, gave the first account of two and a-half years' of systematic experimenting on the possibilities of an aerial photographic survey of large areas of inaccessible and unknown country. The experiments are conducted on behalf of a committee of the Air Force and the Army and Navy, and the operations carried out over the flat Fens north of Cambridge, have impressed the experimenters with the great difficulties of direct mapping, and with the necessity of a very efficient training of the crews employed on the work. Insufficient training, Professor Melvill Jones pointed out, accounted for the failure of some recent mapping experiments made in India. On the other hand, direct aerial mapping brought out details that no ordnance map would give, and was very useful for watching the gradual developments of coast lines and estuaries and of rapidly-growing industrial districts. The staff in charge of the experiments confined themselves to the study of mapping when flying at a steady height, mostly 10,000 ft. above ground, and first ascertained how far constant conditions of flight could be maintained without fatiguing the pilot by having to watch too many instruments. It was difficult to fly along a straight course, and still more so to approach a definite point on a straight course. When the pilot kept his eye on the horizon, to maintain the level, he could not at the same time search the ground below. They found it possible to keep direction and level constant within 100 ft. and to keep the camera vertical within 2 deg. The wind drift to be faced at 10,000 ft. had first to be ascertained by preliminary flights, in which the Wimperis wind gauge was very useful. In fitting the parts of the photograph together, they glued the films to two rubber bands and placed them on glass tables with the rubber bands crossing from left to right; by pulling the bands, fair fits could be obtained, provided they had three reference points on the ground. In unknown territory, partial triangulation aided by preliminary flights to find some reference points, was a great help. On hilly ground perspective distortion might make fitting of the parts impossible. As long as the hills did not rise above 300 ft., however, they were able to map 100 sq. miles in a day; no points should be displaced by more than 100 yards, even when they had no good survey to assist them. Such direct mapping might still answer when the hills rose up to 600 ft.; above that height, the method failed. The maps would not give any height data. With control points 50 miles apart (in unknown territory) an accuracy within $\frac{1}{4}$ or $\frac{1}{2}$ mile might be realised; with control points 1 mile apart, an accuracy of 10 yards was easily obtainable. Professor Jones did not give any information as to cost, but insisted on the necessity of efficient crew training and of not attempting to do too much in a day; the nervous strain of the work was severe.

Heat-Resisting Glasses.

The need for glasses capable of withstanding sudden, and in some cases great, changes of temperature without fracture, is one which is fully realised in many industries, notably those requiring miners' lamp glasses, water gauge glasses, &c. Professor W. E. S. Turner, D.Sc., in a lecture before the Society of Arts, on Wednesday, the 28th ult., on "Heat-Resisting Glasses," pointed out that many attempts had been made to produce glasses possessing the necessary qualities, the efforts generally having been in the direction of treatment of the glass after manufacture in a manner somewhat similar to that now adopted by metallurgists for the heat treatment of steels. The results, however, had been anything but satisfactory owing to the extreme uncertainty of the effects obtainable. Lately, however, the problem has been attacked from another direction, investigation showing that the "thermal endurance" of a glass varied inversely as the coefficient of expansion, which in its turn is dependent upon the chemical composition. Further researches showed that the use of B_2O_3 (boric oxide) and SiO_2 (silica) lowered the coefficient of expansion, and in "Pyrex" 11·90 per cent. B_2O_3 and 80·62 per cent. SiO_2 are used, which give a coefficient of expansion of $37{\cdot}2 \times 10^{-7}$, whereas an ordinary silica-lime glass is about 100×10^{-7}. A drawback however, is the difficulty of manufacture due to the high melting temperature necessary and the very short range of plasticity; this has led to the investigation as to the possibility of using the oxides of zirconium, thorium and titanium. Up to the present the results obtained show that although the glasses produced possess greater mechanical strength, at the same time they also introduce additional disadvantages. In the discussion which followed Dr. Turner's lecture, the chairman, Sir Charles A. Parsons, K.C.B., mentioned the debt owing to the lecturer not only for his own researches but also for collecting the results of the investigations of other workers. Sir Herbert Jackson said that the introduction of TiO_2 in quantities up to 5 per cent. increases the workability in the blow-lamp flame and also that the use of the oxide of thorium increases the range of plasticity. Sir Richard Paget urged the advantages of pure fused silica, which he said has a coefficient of expansion only one-seventh that of "Pyrex." A small collection of articles showing the application of heat-resisting glasses was on view in the lecture hall.

THE OPENING OF THE GENERAL ELECTRIC COMPANY'S RESEARCH LABORATORIES.

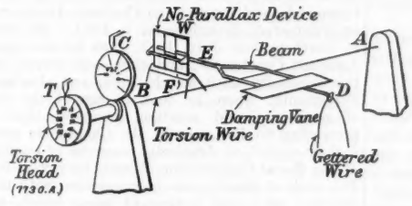
THE opening of the Research Laboratories of the General Electrical Company was a memorable event and more than 700 visitors, comprising many men of eminence in various fields, accepted the invitation to attend the ceremony which took place at Wembley last Tuesday afternoon. They came to inspect the new laboratories—which we describe in the earlier portion of this issue—as well as to see the demonstrations with which we now propose to deal.

The wealth of instructive demonstrations, carefully arranged to exemplify the various activities of the laboratories, was almost embarrassing. Practically all the appliances exhibited were made in the laboratories. The designs of many reflect great credit on the ability of their originators. In the spirit of hearty co-operation, however, prevailing at Wembley, members of the staff deprecate that particular designs should be credited to individual workers. There is a free and constant

interchange of ideas between the members, apart from the frequent conferences. To be fair, we add a list of the chief workers: Messrs. A. C. Bartlett, Norman Campbell, B. P. Dudding, E. M. Eden, C. G. Eden, L. D. Goldsmith, B. S. Gossling, F. S. Goucher, R. Huddart, L. B. W. Jolley, R. Le Rossignol, W. G. Llewellyn, G. C. Marris, C. C. Paterson, J. W. Ryde, W. Singleton, C. J. Smithells, Mark Thompson and H. Ward. The laboratory personnel consists of about a hundred workers.

Reverting for a moment to the lamp-making factory, we should in the first instance correct a statement made on page 258 of this issue. The electrode wires are fixed merely by squeezing the heated end of the flanged tube, the wires being so held that they are gripped in the right position.

Fig. 1. GETTER TORSION BALANCE. TYPE A



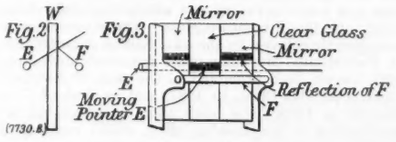
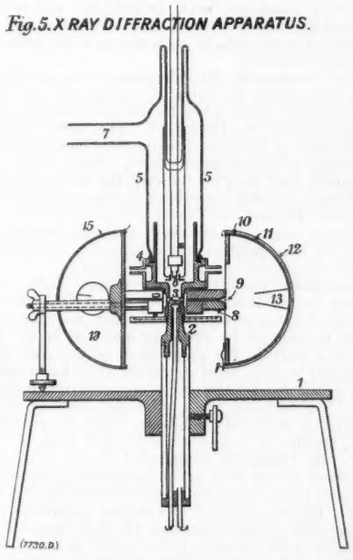


Fig. 5. X RAY DIFFRACTION APPARATUS.

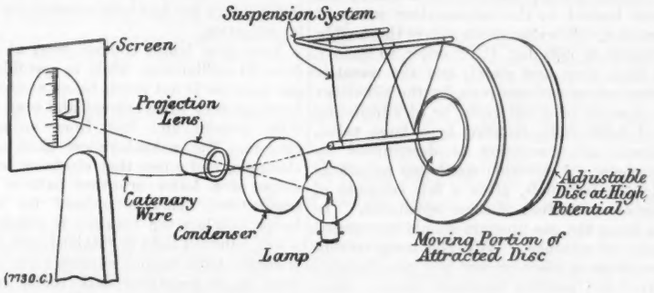


Some novel instruments are used for controlling the masses of materials. We may first mention the torsion balances for the rapid determination of small weights. In the "no parallax" torsion balance type A (Fig. 1) the torsion wire A B is fixed at A, and the B end can be twisted by turning the torsion head T, which is divided into 200 divisions. The disc C geared from T counts the number of half turns. At the centre of A B is fixed a light steel beam D E, which is forked to bear a damping plate, and is provided with a hook at D, from which the filament to be weighed is suspended; the other end E acts as a pointer and is viewed through the stationary window W. This window is supported from the table and is divided vertically into three panels: the two outer panels are silvered, the inner is bare glass. In front of W, at the same distance from W as E, the wire F is fixed (Fig. 2). The observer sees the reflection of F in the two mirrors; through the bare glass he further watches the pointer E. When the beam is deflected by the weight of the filament he will see three broken lines, as in Fig. 3, two being reflections of parts of F, and the middle section showing the portion of E. When the balance has been adjusted for proper weight by turning the torsion head, the three sections will be in alignment. The distinctive feature of the balance is that parallax is avoided in taking readings. The balance is used for determining the ratio of the weight of the "getter" varnish on the wire to the known weight of the uncovered wire. This weight is occasionally checked by passing the getter wire through hydrofluoric acid, which dissolves the getter varnish, and reweighing. The scale is not in milligrams but half a turn of T corresponds roughly to a milligram, so that 0·01 mg. can be read, while the dial C reads up to 6 mg.

In the more rapid B type of torsion balance, the beam D E is fixed nearer to the A end of the torsion wire, and the motion of A, in front of a screen, is watched through a lens giving a magnification of 15. The third C type of balance resembles the B type and serves for weighing spiral lamp filaments, which are sorted by weight, up to 30 mg. In this case the hook is forked, and the screen bears a scale of milligrams and tenths of a milligram, above and below a zero line. In the C type, moreover, the damping vane is mounted vertically, so as to move up and down in the gap between two horizontal horseshoe magnets. In sorting filaments a standard filament or weight is first placed on the hook, and the torsion of the wire is adjusted until the image of the beam pointer coincides with the zero.

The catenary electrostatic voltmeter (Fig. 4) looks like these balances, but is an altogether different instrument. It is designed for measuring momentary high-tension potentials such as arise when the primary of a transformer is broken. There are two metallic discs facing one another. The outer disc can be shifted to an adjustable distance; the second disc consists of two separate parts, an inner disc and an outer guard ring. The inner disc is fixed to a horizontal rod which is suspended by a pair of V threads. To the end of the rod a loose catenary wire is attached. When the small disc is attracted by the charge put on the large disc, the catenary wire is tightened; the middle portion of this wire is optically projected on a scale. By shifting the large disc the same scale can be utilised for various ranges, from 200 volts up to 60,000 volts (root mean square values). The actual range of the disc movement does not exceed 0·04 cm., and with a disc distance of 1 cm. the scale corrections are hence inappreciable. The instrument is standardised by means of an electro-dynamometer. The X-ray diffraction apparatus, illustrated in Fig. 5, consists of an X-ray bulb of the Siegbahn-Shearer type and a double camera of the Debye type. The table 1 supports the copper anode 2, water-cooled, this being flat on the top, while above it is the cathode (tungsten filament) 6, the latter enclosed in a glass bulb 5, joined to the pump. The anode sends the rays in all directions; the rays used glance off at an angle of about 5 deg. from the anode to pass through the aluminium windows 3, and the slit 8 into the two semi-cylindrical cameras and on to the diplitised X-ray film 11, placed between the black paper cover or thin sheet of nickel, 10, and the sensitising screen 12, which is backed by a brass spring strip. The lead baffles 13 prevent straying of the rays, and 15 marks the light-tight cover; 14 gives a view of the left-hand camera. The specimen 9 is placed in front of the horizontal slit between two gunmetal plates; it is a piece of paper (glued to the front of the slit plates) on which the powder to be examined is rubbed; in the diagram the dot 9 indicates the streak of this powder (it might also be a wire) in cross section. For X-ray spectroscopy the crystal to be studied is placed on the anode. Two exposures, extended for hours if necessary, can be made at the same time. The X-ray diffraction patterns shown in Fig. 6 exemplify how mixtures of salts, like sodium chloride, NaCl, and potassium bromide, KCl, are analysed. The mixture shows the lines of both the constituents—the lines are, of course, not spectrum lines in the ordinary sense, but diffraction lines.

Fig. 4. HIGH-TENSION CATENARY VOLTMETER.



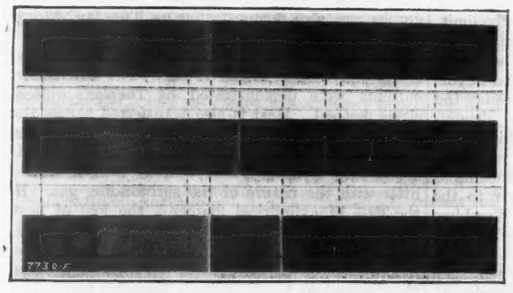
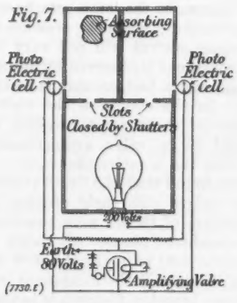


FIG. 6.

Fig. 7.



A new problem under investigation is the X-ray danger that may arise from valve tubes, especially when, during their exhaustion, potentials exceeding 10,000 volts are applied. The ordinary bulb glass contains enough lead (about 18 per cent.) to be fairly impervious to X-rays, but the special silica tubes are permeable to the rays.

The photoelectric photometer (Fig. 7) measures the "blackness," *i.e.*, the absorbing power for light, of any substance, even if of irregular shape and not equally black all over, such as the patch in the diagram, and it is utilised for determining the blackness of the inside coatings of lamps tarnished by use. Diffused light from a source contained in a white box enters two cylindrical chambers through slots provided with shutters. Normally the illumination is the same in the two chambers. When a light-absorbing body is placed in the one chamber, the equilibrium is disturbed until it is readjusted by partially closing the shutter of the other chamber. The equality of illumination is determined with the aid of the photoelectric cells which receive their

light through two small holes, one in each chamber. The cells contain metallic potassium which emits electrons when illuminated. The two cells are so connected that no electronic current flows on re-establishing equilibrium, and since the actual currents are very minute, they are amplified a million times by means of the valve seen at the bottom of the diagram. An accuracy within a fraction of 1 per cent. is easily obtained.

The "current-divider" supplies submultiples of known currents for photoelectric and other purposes. A large current flows between a hot wire and a cylindrical anode. Through a small hole in that anode, of 0·0001 of the anode area, passes a small fraction of that current into a Faraday cage; the area ratio gives the current ratio.

High vacua are produced in the valve development laboratory by a combination of pumps, a mercury vapour pump, backed by a rotary oil pump, itself backed by the reciprocating pump of the sub-station. To exhaust the valves thoroughly they are baked at 400 deg. C., in order to remove gas films from glass and metal, and the metal is then bombarded by cathode rays, by the aid either of direct currents of 4,000 volts, or of alternating currents of 5,000 volts, rectified by a large valve.

The degree of evacuation is determined by several methods. A portable spark-gap apparatus applied to the terminals, gives a fair estimate of the degree of evacuation of some apparatus. In a vacuum lamp the gas pressure should not exceed 0·0002 mm. of mercury. With the lamp current on, a thermionic or space current will pass between the negative and positive terminals inside; when the pressure is above the limit stated, that current will change, as the lamp gets hotter with increasing lamp current; when the pressure is below the limit, the space-current will not vary with temperature. The constancy is observed by means of a Wheatstone bridge, and a bad vacuum is easily detected in this way. In the course of the visit last Tuesday the reality of these space-currents was also demonstrated by a valve arrangement in which they brighten the negative electrode.

It is found that the "dull-emitting" filaments of some valves owe their peculiar behaviour to the admixture of thoria with tungsten. At Wembley, as elsewhere, nitrate of thoria is added to the tungsten acid to make the wire stronger—which it does in some little-understood way. When such a thoria-tungsten filament is heated to 2,600 deg. C. a chemical reaction takes place in the wire according to Langmuir; at the lower temperature of 2,000 deg. C. some metallic thorium is supposed to diffuse to the surface. Now less work is required to make electrons escape from thorium than from tungsten; at the same temperature 100,000 electrons are indeed supposed to escape from thoria to one escaping from tungsten; hence a thoria-filament can be worked at much lower temperature, that is, at lower current. If, then, an ordinary tungsten filament requires 2·8 watts at 4 volts to give a certain number of electrons, a thorium-tungsten dull-emitting filament will give the same number of electrons with 0·58 watt at 1·6 volt. Unless specially treated, however, the ordinary thoriated filament has the same electronic emission power as the pure tungsten filament—this supports the assumption of a film of metallic thorium—and the special treatment makes the thorium filament liable to oxidation in a poor vacuum; but these troubles have been overcome and valves of lives of 5,000 hours have been produced.

The method for the micro-analysis of gases by the use of the Pirani pressure gauge is based upon the characteristic vapour-pressure/temperature curve. When the gauge contains several vapours, but no permanent gases, and the temperature is raised from a value below the condensation temperature of the least condensable vapour, the pressure is seen to rise in steps corresponding to the vapour pressures of the several substances. When gases like hydrogen and oxygen are present, they are first converted into vapours by introducing an electrically-heated copper wire coated with cuprous oxide. The method is used for testing one of a set of valves, which, for this purpose, is provided with a lateral tube. This tube is dipped successively into various freezing agents, finally liquid air. The gauge which Pirani described in the *Physikalische Gesellschaft* in 1906 acts on the principle, which has many applications, that the rate of cooling of a wire depends upon the surrounding atmosphere. The wire temperature is measured on a Wheatstone bridge, which Dr. Campbell arranges in such a way that the resistance of the wire is kept constant. Vapour pressures between 0·1 and 0·001 mm. of mercury can be determined. This method can be applied to the gases contained in the bubbles of glass. Generally, however, spectroscopic analysis is sufficient in these cases. The fragments of glass are then placed in a silica tube (branch of a large tube), which is heated to drive off surface-gas films; this gas is pumped off. The tube is then heated to higher temperatures, and the mercury, contained in the cold main tube, is suddenly jerked over the hot glass, which is thereby shattered. The tube is cooled in cold water, and the process is repeated until enough gas has been released for spectroscopic investigation.

Neon glow lamps contain neon at a pressure of 5 or 10 millimetres, while in gas-filled lamps the gas pressure is not much below atmospheric; they consume very little current and may be worked at 0·02 ampere and less from ordinary 200-volt circuits. The reddish-yellow glow surrounds the electrode, and when that electrode is made in the shape of a letter or other pattern that pattern stands out. This is utilised for advertisement lamps. When the filament is coiled into a cone a soft, subdued light is obtained, and when the bulb is coated with various varnishes the lamps may be used in photographic dark rooms for developing diverse sensitised plates. The use of neon lamps (and lamps containing other rare gases) as oscillographs was also demonstrated on Tuesday during the visit.

In gas-filled lamps convection currents and gas layers may cause some trouble. The convection currents were demonstrated by Toepler's optical striae method. Heat is also transferred across the layer of gas surrounding the spiral filament of lamps of this type. The thickness of this conducting layer is about 2 mm., and it varies little with the nature of the surrounding gas. In the case of cylindrical filaments the loss of heat from the wire through the gas increases, of course, with the length of the wire, but it is, within limits, independent of the diameter of the wire. Spiralling the filament to a coil of small diameter hence does not increase the heat loss to the gas as much as using long wires would do, when a larger glowing surface is wanted, and that is one of the reasons why the filaments of gas-filled lamps are spiralled.

Microscopy is largely resorted to in the laboratories, for instance, in the study of copper-coated nickel leading-in wires, which are now being substituted for platinum wires. The number of grains in a wire in a tungsten bar is counted by throwing an image of the illuminated cross-section, magnified 400 diameters, on a glass screen over which a sheet of tissue paper is placed; with the aid of a pencil the observer traces out the grains as he sees them on the paper and counts them afterwards. The mounting of the finest tungsten wires for microscopic examination is effected in the following way. In a small mould, merely a grooved plate of metal, a little glass of low-melting print is fused; the wire is dropped into the molten glass; when the glass solidifies, the wire is polished in the mould together with the glass. The manner in which residual water vapour may destroy the spiral tungsten filaments was already noticed on page 102 of our issue of July 15, 1921, when Mr. C. J. Smithells read a paper on "High Temperature Lamp Phenomena" before the Faraday Society; the researches are being continued, and the snapping of the wire is being studied with the aid of a kinematograph.

We conclude by giving expression to our best wishes for the prosperity and success of the General Electric Company and their Research Laboratories.

THE LATE MR. H. R. CHAMPNESS, M.V.O.

AN architect whose work must have contributed in no small measure to the successful issue of the war from the naval standpoint, has passed away in the person of Mr. Henry Robert Champness, M.V.O., who died at his residence at Wandsworth Common, on Thursday, the 22nd ultimo, after a brief illness. Mr. Champness, who was in his 71st year, was assistant Director of Naval Construction at the Admiralty at the time of his retirement in November, 1913, having held that position for eleven years as the assistant of Sir Philip Watts. It was during that period, of course, that the various Dreadnought cruisers from the Invincible to the Lion, were built, and the fact that Mr. Champness was mainly occupied with the construction of these vessels, which gave such an excellent account of themselves during the war, is sufficient grounds for the suggestion that the work of the deceased gentleman was by no means without influence on the outcome of the struggle.

Mr. Champness was born on June 18, 1852, and the fact that his father was in the Admiralty service as an inspector of timber, doubtless influenced the selection of the son's career. The subject of our memoir after receiving his elementary education at Old Brompton, Kent, became a shipwright apprentice at Chatham Dockyard in 1866, where he remained for four years. He entered the Royal School of Naval Architecture at South Kensington in 1870, completed his course at Greenwich, and returned to Chatham Dockyard as a supernumerary draughtsman in 1874. He remained at Chatham until July, 1883, when he was appointed Assistant Constructor, 2nd class, and served, first at the Admiralty until March, 1886, and afterwards at Portsmouth, where he took charge of the drawing office. We should mention, however, that before proceeding to Portsmouth, Mr. Champness acted for a short period as Admiralty overseer of shipbuilding at the Naval Construction Works, Barrow-in-Furness. His work at Barrow was in connection with the construction of scouts, a class of vessel which, at that time, was much in favour and which eventually developed into the Adventure class. These vessels were subsequently eclipsed by the introduction of destroyers. At Portsmouth, Mr. Champness remained until July, 1895, having been promoted to the rank of Assistant Constructor, 1st Class, in 1887, and to that of Constructor in 1889. His work there included the reorganisation of the drawing office, which rendered it capable of preparing the working drawings of the ships built under the Naval Defence Act and of the vessels of the Royal Sovereign class. After his appointment as a Constructor, he took charge of the building work at Portsmouth.

From Portsmouth, Mr. Champness was appointed Chief Constructor at Malta, occupying this position until February, 1897, when he was transferred, in the same capacity, to Devonport. The more notable vessels built at Devonport while Mr. Champness was in charge of construction there, which was until November, 1902, were the Bulwark, the Implacable and the Ocean. In 1902, the subject of our memoir became Assistant Director of Naval Construction at the Admiralty, where he remained until his retirement, which we may mention was delayed for over a year beyond the official age limit of 60 years.

Throughout his life, Mr. Champness took great interest in the Royal Corps of Naval Constructors, of which he was, of course, a member, and spared no efforts to promote its efficiency and well being. He also took part in the preparation of the Admiralty scheme for training naval architects, which has certainly been responsible for the production of several eminent men. The deceased was a prominent member of the Institution of Naval Architects, which he joined in 1884, serving as a member of Council from 1907 to 1921. He frequently contributed to the discussions on papers dealing with naval construction matters, as reference to the earlier volumes of ENGINEERING would show. He was, however, of a modest disposition, and did not seek public recognition, although he was made a Member of the Victorian Order in 1902 on the occasion of the launch of one of the battleships constructed under his direction at Devonport; on several occasions he received the special thanks of the Admiralty Board for some particularly satisfactory piece of work. He was married in 1880 to the daughter of Mr. C. R. Quiller, of Chelsea, and leaves three sons and two daughters. The interment took place on Monday last at Putney Vale Cemetery.

INDUSTRIAL NOTES.

Two articles have been published in *Le Génie Civil*, Paris, dealing with "The Eight-Hour Day and its Effect upon Output." After referring to the historical part of the measure and of preceding legislation, the author states that in the coal mines the working day is generally less than seven hours. The secretary of the Lille Chamber of Commerce says the miner now has an effective day's work of 6¼ hours only, and the coal output is generally falling. In metallurgical works the eight-hour day has led to an increase of 45 per cent. to 50 per cent. in the number of workmen. In metallurgical continuous shift trades (blast furnaces, &c.) and in the engineering industries, the decrease of production due to the eight-hour day amounted to 10 per cent.

The cost of agricultural machinery has increased by 15 per cent. to 25 per cent., owing to the same measure. It has led to an increase in the staffs of the main French railways; these employed 352,045 operatives in 1913, and 493,263 in 1920; in 1913 the wages and salaries amounted to 806,000,000 francs, equal to 40·7 per cent. of the receipts, whereas the figure for 1920 was 3,408,000,000 francs, equal to 59 per cent. of the receipts. The eight-hour day measure costs French shipping and general navigation 180,000,000 francs per annum. On cargo boats it represents an additional annual expenditure of 84 francs per ton. When comparing the production in the textile industry for 1913 and 1919, it is found that the decrease in production is often 25 per cent. and occasionally reaches 40 per cent.

The articles from which we quote state that the eight-hour day measure is largely responsible for the present economic crisis in France, for the high cost of living and the disorganisation of the country's finances. They add that the eight-hour day measure is applied in France alone, the other countries allowing modifications which render it less harmful. "In England," for example, "the eight-hour day has followed upon agreements entered into by the trade unions and the employers."

We may say, however, that the United Kingdom is not one of the countries who allow modifications in the eight-hour day. This, on the contrary, is strictly adhered to, and schemes are even on foot to reduce still further the number of working hours. Nor is the United Kingdom among those countries in which overtime is allowed. In France the men gladly work overtime in order to increase their wage, a fact which we have ascertained repeatedly. One recent instance of tyranny at home in this respect is that of a foundry worker, of Rochester, who was fined 2*l.* by his union for daring to work an extra 45 minutes in order to finish a casting.

A report reaches us of a mass meeting, held in London, of operatives employed in the wholesale textile warehouses, convened by the National Union of Distributive Workers, when it was determined to resist any increase in working hours and to retain the 44-hour week. Mr. R. J. Wilson, M.P. for Jarrow, stated that if the workers were disunited the employers would force upon them the 48-hour week.

The Lanarkshire miners, with the approval of Mr. Robert Smillie, have recommended a policy of working 11 days a fortnight in order to secure uniformity. Several pits are at present working six days weekly, others are working five, whilst others already have the 11 days' policy. The scheme has been put before the miners, who will decide within the next fortnight.

Reports come to us from different parts of the country to the effect that blast furnace owners are in great difficulty at the present time owing to lack of coke, by reason of excessive exports to the Continent.

We referred recently (see pages 72 and 105 *ante*) to the disputes which had occurred in the matter of wages and hours of labour in the building trades. Meetings have been held regularly of late between the employers and the men, and the final terms of the former are as follows:—"Should the operatives consent to a further agreement involving a reduction in wages for twelve months of 2*d.* per hour in 'A' grade towns, and other reductions proportionate in all grades of labour, with a minimum reduction in the crafts of 1*d.* per hour in the lowest grade towns, then the employers agree that the 44-hour week (41½ in the winter) be allowed to continue until March 31, 1924, but without prejudice to the employers' present position, which now exists, owing to the National Wages and Conditions Council at their meeting, February 14–15, 1923, having failed to arrive at a decision.

"Provided that—where longer hours are being worked to an appreciable extent by building trades operatives in any town or district, (*a*) for employers in other industries, (*b*) for unfederated employers—the parties hereto agree to take joint measures forthwith to devise means for preventing the position of the federated employers from being prejudiced under the agreed working conditions."

The men are to ballot on these terms. The ballot papers state:—"1. I am willing to accept the employers' proposals for the stabilisation of hours of labour and wage rates for twelve months on condition that the following wage rate alteration takes place, namely, towns graded A, A1, A2 and A3, 2*d.* per hour; B, B1 and B2, 1½*d.* per hour; B3, C, C1 and C2, 1*d.* per hour; the labourers' rate to be not less than 75 per cent. of the craftsman's rate.

"2. I am against acceptance of the employers' proposals, and am fully prepared to accept the consequences of rejection, either by strike or lock-out."

The ballot papers are returnable on the 12th inst. at the branches, and two days later at the National Federation of Building Trades Operatives. It is stated that if the above terms are not accepted the employers will reserve the right to revert to the terms which we gave on page 72 *ante*. In the case of a strike as many as 500,000 operatives would be involved. A 20 per cent. majority against the employers' proposals would be required for a strike to be declared.

The Prime Minister received last Tuesday, the Executive of the Miners' Federation, including Mr. H. Smith, President, and Mr. F. Hodges, Secretary. The interview lasted one hour and a-half. The Executive then held a meeting, at the close of which they issued the following statement:—"The Executive of the Miners' Federation met this (Tuesday) afternoon to consider the reply of Mr. Bonar Law to their request for an inquiry into the general wage position of the miners engaged in the coal industry, with a view to advancing the minimum wage of the miners, so as to correspond with the present cost of living. In view of his unsatisfactory reply, it was decided that a special conference of the delegates of the Federation be held in London on March 27, to receive a report from the Executive, and to decide on the course of action to be taken thereon."

An article by Sir Frederick Henderson, ex-President of the Shipbuilding Employers' Federation, in *The Yorkshire Post*, states that whilst actual shipyard costs are, approximately, 40 per cent. above pre-war, the outfit, machinery and accessories that need to be brought in to complete the equipment of the ship range from 80 per cent. to 120 per cent. above pre-wat; coal and power from 60 per cent. to 70 per cent.; rates and taxes are well above 100 per cent. more. Railway charges alone have increased the cost of steel used in building a ship by about 15*s.* a ton more than pre-war. In other words, while the prime contractor goes without profit, and his workmen with wages much below the cost of living, the auxiliary trades and occupations which serve shipbuilding—and other industries—include in their charges both profit and much higher wages. It is because of this that shipbuilders cannot get orders at a price which will insure them against loss. No shipbuilder dare fill his yard with ships, even if orders were available, at present prices. And thus employment is curtailed and unemployment continued. All the largest industries have learned the folly of maintaining costs at a level beyond the purchaser's price, but subsidiary occupations and services have still to effect adjustments in their remuneration before prosperity can return. The crank of productive industry is, in fact, struggling to revolve, but cannot get moving for the back pressure of artificial costs at home, which are out of all proportion to conditions in the world's markets.

In regard to wages, Sir Frederick says that the complete topsy-turvydom of present wage arrangements is seen at a glance if one casts an eye down a table like the following, which gives approximately the average position, taking the country as a whole:—

	Weekly Rates of Wages. Pre-War		Now.	
	s.	*d.*	*s.*	*d.*
Miner	40	0	52	0
Steelworker	40	0	48	0
Shipwright	41	6	48	6
Engineer	39	0	56	0
Tailor	40	0	70	0
Baker	32	0	66	0
Shop assistant	30	0	60	0
Compositor	35	0	80	0
Railway Porter	21	0	53	0
Carter	25	0	53	0
Dustman	27	0	63	0
Tramway driver	30	0	58	0

The general lesson of this table is that the increases in the wages of the highly-skilled workmen in competitive trades is much lower than the increases in the semi-skilled and unskilled occupations—a complete reversal of the pre-war relationships.

According to some people, says *The South African Mining and Engineering Journal*, the gold mines are run solely in the interests of overseas capitalists and are thus of little value to South Africa. The absurdity of this statement is evident by reference to the following, extracted from the last report of the Government Mining Engineer, *i.e.*, that for the year 1921. During that year the mines produced a total revenue (after allowing for realisation charges, exchange, &c.) of over forty million pounds. During that year the mines paid in South Africa the following large sums:—Salaries and wages to Europeans, 10,340,000*l.*; native wages, 5,775,000*l.*; stores (of which nearly ten millions were in respect of South African products), 14,000,000*l.*; direct taxation, fees and miners' phthisis expenditure (mostly spent in South Africa), 2,000,000*l.* About eight millions were available for dividends, interest, redemption of debentures, and repayment of loans, and as something like half the shares of the dividend-paying gold mines are held in South Africa, it is evident therefore that out of the forty millions produced by the mines, not less than thirty millions were paid out in South Africa.

The same journal states that the number of whites employed in the gold mines in the Transvaal in April of last year was 14,434. In December, the number had risen to 17,611. It adds that in all probability the number will be close upon 19,000 by the middle of the current year.

SUGGESTED SPECIFICATION FOR PERMANENT MAGNET STEELS.

To the Editor of Engineering.

SIR,—While the article by Professor Crapper, published in ENGINEERING for February 2 (page 129), is of value as summarising the present state of the art in respect of the manufacture of permanent magnets, it would seem that Professor Crapper has not laid sufficient stress on what is really the true criterion of a permanent magnet, or a piece of magnet steel.

The standard by which any magnet is eventually judged is the cost of producing a given magnetic flux. Since this flux is in all cases associated with a certain demagnetising force dependent on the conditions, it is equivalent to saying that a given amount of energy has to be maintained in a circuit external to the magnet itself. Now, the cost of providing this energy may, roughly, speaking, be divided under two headings, firstly, the cost of the magnet itself, and, secondly, the cost of housing it. So long as the latter item can be neglected it is at once evident that the true criterion is the ratio of available external magnetic energy $= \frac{(B\,\phi)_{max.}}{8\,\pi}$ to cost per cc. of the finished magnet. At the present time this quantity has the following approximate value for straight-bar magnets cut off and hardened only, with no allowance for machining, bending, grinding or finishing:

	Ergs per Penny.
1. Low-grade chromium steels ...	56,000
2. High-grade tungsten steels... ...	34,000
3. Cobalt chromium steels (medium cobalt)	22,000
4. High-cobalt steels	21,000

It is not proposed to consider these further, beyond pointing out that they indicate that provided the lower-grade steel can be employed without the necessity for additional cost being entailed in housing it, or in bending it to a complicated shape, the use of the more expensive alloy is not economically justifiable.

Having granted that the true criterion of a magnet is the $B\,\phi_{max.}$ figure, we may ask ourselves to what extent the other properties need be considered by the engineer, or user of the magnet, as apart from the physicist. It is clear that if the best use is to be made of the magnet, it is necessary that it shall be worked at the point at which $B\,\phi$ is a maximum, and in order to enable us to do this, it is necessary for the user to have in his possession the BH curve of the magnet.

Recent work has shown that the BH curve of a properly-hardened magnet is fully determined if any three points on it are given, so that if we know the values of the remanent intensity I_R and the coercive force, H_c, in addition to the value of $(B\,\phi)_{max.}$, we are in a position to draw the BH curve, and to design an apparatus in such a way that the magnet is properly utilised. As Professor Gray has pointed out, any other three parameters might be used to define the curve, but the three usually chosen, viz., $(B\,\phi)_{max.}$ I_R and H_c, possess the advantage of being readily measured with simple apparatus.

There are certain points in Professor Crapper's paper to which exception may be taken: For example, it is difficult to see what justification he has for regarding the product of $H_c \times B_{rem.}$ as being the magnetic strength of the magnet. The product $H_c \times B_{rem.}$ was largely used at a period several years ago, when our knowledge of permanent magnets was less complete than it is now. Now that we have other and better criteria, it is no longer necessary, and should be discarded. To suggest that it represents magnetic strength in any way is erroneous and misleading. The introduction of the coefficient of retentivity c as a property of the material, and the assignment to it of definite values is a daring step. Our knowledge of this coefficient is very incomplete, but one thing is certain, and that is, that it varies very considerably in magnets from a given steel, with different methods of hardening and heat treatment. The writer's own experience is that for a properly-hardened steel, of correct composition, C has approximately the same value, 0·67, for all classes of steel, but an incorrect heat treatment, or the presence of some constituent in excess, may easily bring this down to as low as 0·55, or even lower in extreme cases.

Professor Crapper does not state the physical meaning of the product $H_c \times c$, and it is difficult to see what significance this can have, while again the value of the ratio $\frac{H_c}{I_s}$, although of theoretical interest, is not of use to the designer, and only serves to confuse the issue. With Professor Crapper's views as to the necessity for establishing a definite grading of the steels now available, the writer is in entire agreement, but he would suggest that this be done entirely on the basis of $(B\phi)_{max.}$ with the addition of upper and lower limits for $B_{rem.}$ and H_c. It will be found that if a variation of $B_{rem.}$ and H_c of about ± 10 per cent. be permitted, then provided any piece of apparatus is designed to properly utilise a magnet

whose properties are given by the mean values, very little difference in performance will be found with steels comprised within the range given, so long as the (B ϕ) max is the same. In other words, we may say that the variation in B ϕ for a range of 10 per cent. on either side of the maximum point is but small. Anyone who will draw the B ϕ curve for any modern magnet steel will at once realise the truth of this assertion.

Yours faithfully,

E. A. WATSON.

Victoria Works, Coventry, February 20, 1923.

SCIENTIFIC RESEARCH.

TO THE EDITOR OF ENGINEERING.

SIR,—Sir Alfred Yarrow's splendid contribution to the cause of science, recalls his munificent gift of 12 years ago, which rendered possible the building of an experimental tank at the National Physical Laboratory, where, on the Froude system of testing model ships, research work has been carried out which has proved of inestimable value to the shipping interests of this country. The Institution of Naval Architects made themselves virtually responsible for the maintenance of that tank for the first 10 years, and have succeeded in keeping it going, but while its continuance is fully assured, it still lacks adequate support for research work. Through the department of Scientific and Industrial Research the Government are willing to add 1*l.* for 1*l.* to any money that may be raised in the industry for this purpose. About 1,100*l.* (out of 2,500*l.* required from the industry) is contributed annually, mostly by a few public-spirited shipbuilding firms and shipowners. The amount required is small in comparison with the resources of the industry.

It should be realised that:—

(1) British industrial development hinges largely on the shipping of this country.

(2) British shipping interests are dependent, among other factors, on the progress of British shipbuilding, unless they are prepared to look abroad for the future supply of their ships.

(3) Progress in shipbuilding depends, in the first instance, upon scientific research for its advancement.

(4) Foreign countries are to-day fully alive to the need of scientific research in shipbuilding, and to the value of tank experiments.

The experiments now being carried out at the William Froude Tank on models in artificial waves, reproducing to a certain extent conditions met with at sea, are of peculiar interest at the present time and may lead to far-reaching results. Experiments on model propellers are also yielding interesting data, while seaplane model tests bring the work within the sphere of those who are interested in the progress of aviation overseas.

There is, therefore, every reason why shipowners, as well as shipbuilders, should realise that the William Froude Tank, with its unrivalled possibilities for working the untilled field of future development is deserving of that support, upon which our shipbuilding supremacy partly depends.

A list of contributors is appended, and further contributions can be sent to the Institution of Naval Architects.

Yours faithfully,

R. W. DANA.

Institution of Naval Architects, 5, Adelphi-terrace, London, W.C.2, February 28, 1923.

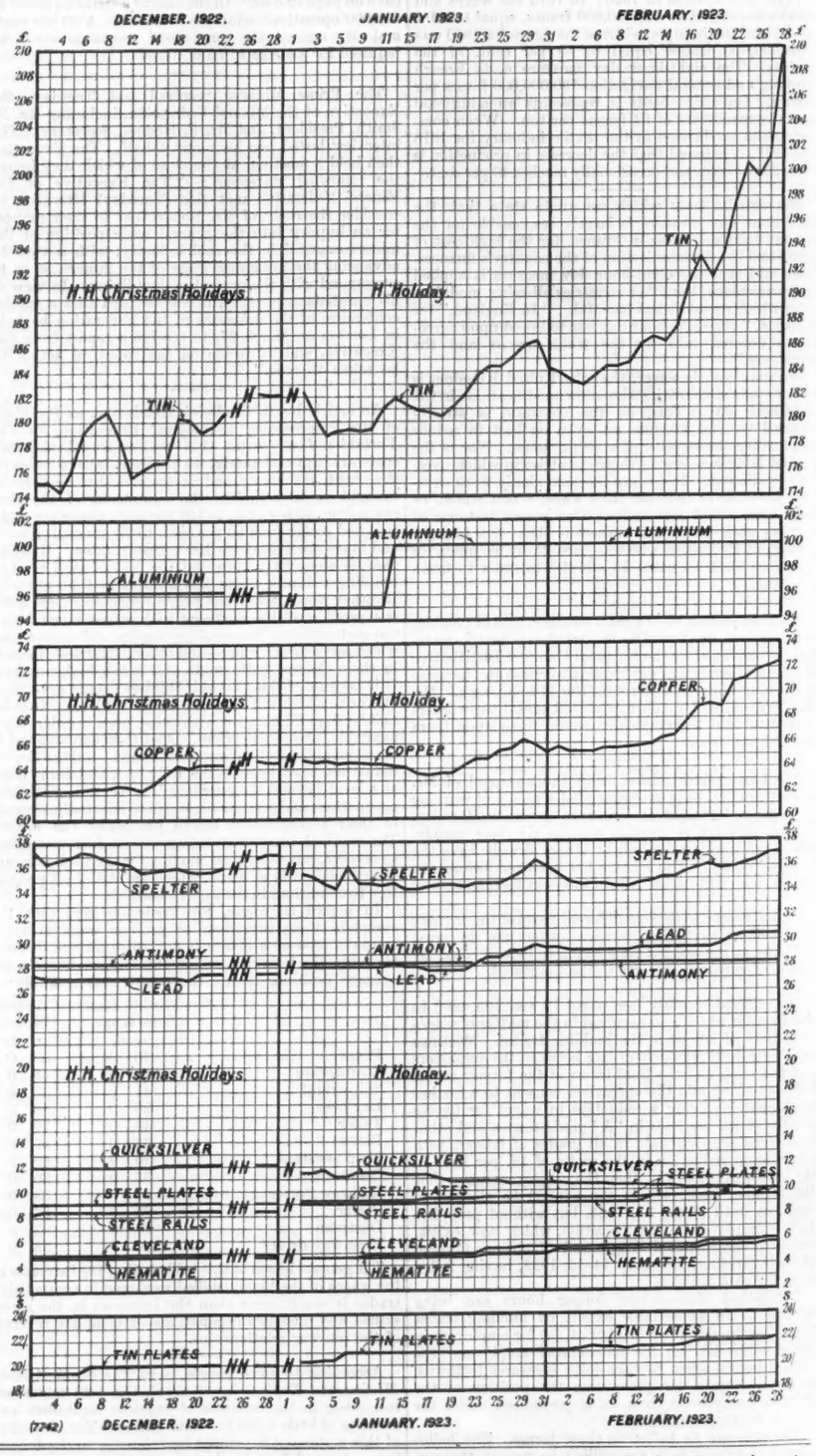
"William Froude" National Tank.
Special Fund for Research Work.

	£	s.	d.
Messrs. Armstrong Whitworth and Co. ...	100	0	0
Messrs. Cammell Laird and Co.	100	0	0
Messrs. Fairfield Shipbuilding and Engineering Company	100	0	0
Messrs. R. and W. Hawthorn, Leslie and Co.	100	0	0
Messrs. Lloyds' Register of Shipping... ...	100	0	0
Messrs. Swan Hunter and Wigham Richardson	100	0	0
Messrs. Wm. Doxford and Son	50	0	0
Messrs. The North Eastern Marine Engineering Company	50	0	0
Messrs Scotts' Shipbuilding and Engineering Company	50	0	0
Messrs. J. Samuel White and Co.	50	0	0
Messrs. The Wallsend Slipway and Engineering Company	50	0	0
Messrs. R. Williamson and Son	50	0	0
Messrs. The Parsons' Marine Steam Turbine Company	50	0	0
Messrs. The Royal Mail Steam Ship Company	25	0	0
Messrs. The Union Castle Steam Ship Company	25	0	0
Messrs. J. I. Thornycroft and Co.	25	0	0
Messrs. Wm. Simons and Co.	25	0	0
Messrs. Workman Clark & Co.	25	0	0
Messrs. Canadian Pacific Steam Navigation Company	25	0	0
Messrs The Tyne Iron Shipbuilding Company	21	0	0
Messrs. The China Navigation Company ...	15	0	0
Messrs. The Taikoo Dockyard Company ...	15	0	0
Messrs. C. T. Bowring and Co.	10	10	0
Messrs. Ellerman Bucknall	5	5	0
Messrs. C. M. Salvesen and Co.	5	5	0
Messrs. Earle's Shipbuilding Company ...	5	5	0

"BRITISH TRADE" EXHIBITION SHIP.—The British World Trade Expeditions, Limited, Coventry House, 5–6, Coventry-street, W.1, has purchased the Orient liner Orontes, which will be converted into an exhibition ship to tour the world in the interests of British overseas trade. The sailing date has been fixed for June 2. Further particulars can be obtained from the company.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given in the case of steel plates are for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for the East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lbs. to 80 lbs. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in all other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

THE KITSON-UTLEY ROTARY PUMPS.

CONSTRUCTED BY THE KITSON ENGINEERING COMPANY (LONDON), LIMITED, ENGINEERS, STAMFORD, LINCS.

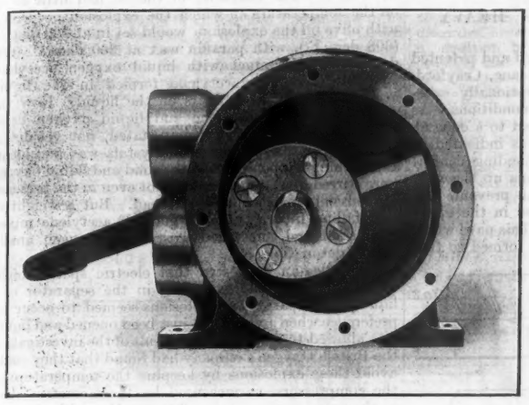


FIG. 1.

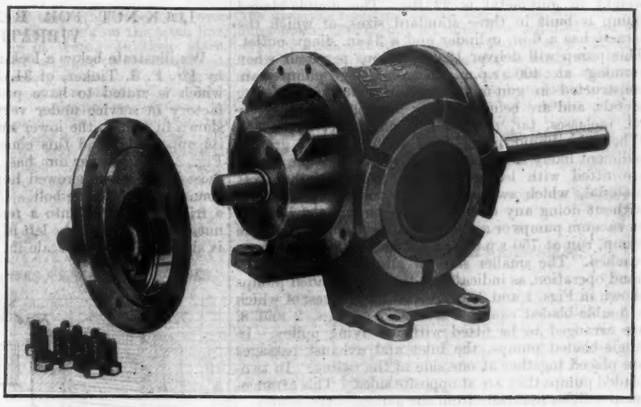
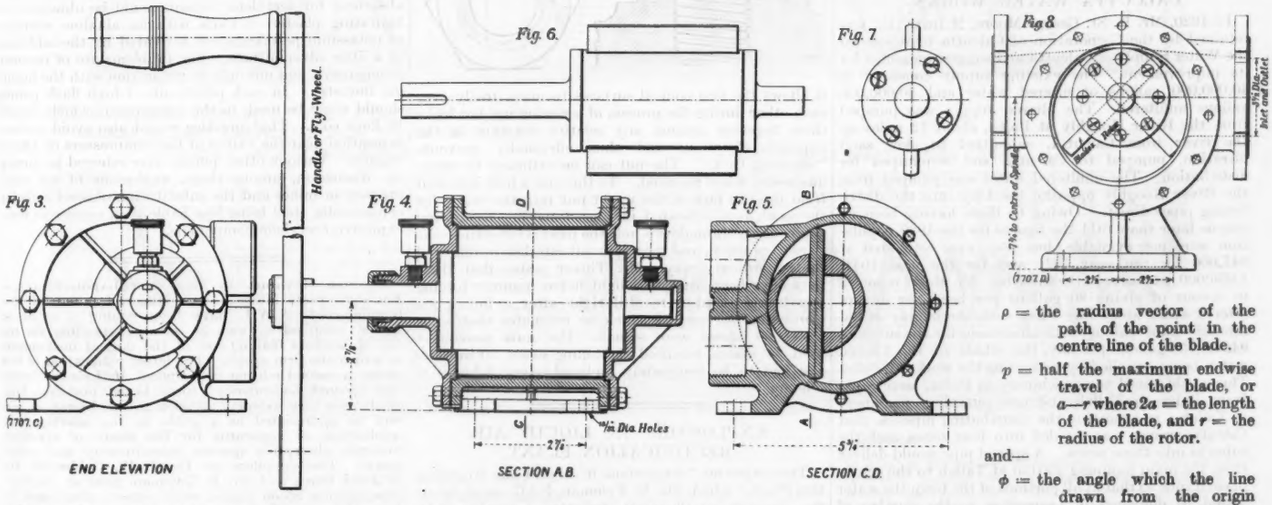


FIG. 2.



AMONG the very many forms of rotary pumps, which have been devised, one of the most usual is a simple arrangement consisting of a drum with an eccentrically set rotor carrying a sliding blade which makes contact at each end with the rotor. With an arrangement of this kind, however, it will be found that the blade cannot make contact in all positions with a circular drum, and various devices have been introduced to cope with this fundamental geometrical defect. These have taken the form of dividing the blade and arranging that the halves shall be forced outward against the drum wall by central springs, or of fitting the rubbing edges of the blade with some form of spring packing. Arrangements of this kind naturally complicate the attractive simplicity of the initial arrangement, and lead to wear of the drum owing to the rubbing pressure exerted by the springs, and much interest attaches to any simpler solution of the problem such as that employed in the Kitson-Utley rotary pump, and illustrated in the figures above. This pump is manufactured by the Kitson Engineering Company (London), Limited, of Stamford, Lincolnshire.

The essential feature of the Kitson-Utley pump is that the interior of the drum forming the blade chamber is so shaped that the ends of the blade are geometrically in contact with the wall in any position, so that no spring control arrangements of any kind are required and the extreme simplicity of the arrangement earlier described is retained. This will be clear from the figures above and special reference may, at this stage, be made to Figs. 1 and 4 to 7, which show the single-bladed pump. The main features of the arrangement are, perhaps, best shown in Fig. 5, from which it will be seen that the rotor is so off-set from the centre of the drum that its periphery is at one point in contact with the inner wall of the drum. The blade is, of course, fitted so that it can slide in the rotor and as this member rotates, both ends of the blade at all times make contact with the drum walls. It is probably hardly necessary to point out that the spaces on either side of the blade vary in volume as the rotor and blade rotate together, rising from a minimum to a maximum and falling again to the minimum in one revolution, so that there are two suctions and two deliveries per revolution.

The blade chamber of the pump is so shaped that for any angular displacement of the blade, an endwise displacement also takes place, this endwise displacement being proportional to the square of the angular displacement measured from the point where the rotor touches the chamber wall. The shape of the chamber may be obtained by making the wall conform to an endless curve, which touches the periphery of the rotor at one point and passes through points plotted on lines radiating from the centre of the rotor, each of which points is distant from the periphery of the rotor by a length along its radius, proportional to the square of the fraction expressed by the ratio of the angle between such radius and the first-mentioned point divided by 90 deg. and also is further proportional to half the maximum endwise travel of the blade. With a blade-chamber so shaped, straight lines drawn from any point on the periphery of the chamber through the centre of the rotor to meet the periphery of the chamber on the opposite side will be of equal length, so that a blade of this length will always have its end in contact with the walls of the chamber throughout the whole of its angular movement.

With this construction of the blade chamber, the path of any point in the centre line of the blade as the rotor revolves on its axis is a curve, the polar equation of which, with the centre of the rotor as origin and the initial line the line of greatest projection of the blade, is of the form :—

$$\rho = p \left\{ \frac{(\pi + 2\phi)(\pi - 2\phi)}{\pi^2} \right\}$$

the signification of the symbols being—

ρ = the radius vector of the path of the point in the centre line of the blade.

p = half the maximum endwise travel of the blade, or $a - r$ where $2a$ = the length of the blade, and r = the radius of the rotor.

and—

ϕ = the angle which the line drawn from the origin to the point in the path makes with the initial line.

The angle ϕ can never be greater than 90 deg., and when the rotor, starting from the point of contact with the blade chamber, has rotated through an angle of 90 deg., the length signified by ρ becomes zero and in passing through zero, changes its sign. The angle ϕ also changes its sign; so that while the rotor is rotating through the angle from 90 deg. to 180 deg., a point in the centre line of the blade is rotating through the angle —90 deg. to —0 deg. The above expression for the path of a point in the centre line of the blade thus, in the second quadrant of the blade's rotation from the point of contact, becomes :—

$$\rho = p \left\{ \frac{(\pi - 2\phi)(\pi + 2\phi)}{\pi^2} \right\}$$

When the rotor has completed its rotation through the angle 90 deg. to 180 deg., the radius vector ρ is again equal to p and changes its sign and the same sequence is repeated, except that the other end of the blade is now in the initial position. Under these conditions, the general mathematical expression, as a polar equation with the centre of the rotor as origin and the line of greatest extension of the blade as the initial line, for the path of a point at the end of the blade, and therefore for the curve of the shape of the chamber, is :—

$$R = a + \rho.$$

Where—

R = the radius vector of the curve of the blade chamber

and—

a = half the length of the blade.

It will be seen that for every variation of the ratio of the diameter of the rotor to that of the chamber, the shape of the curve is altered.

As will be seen from the figures above, the pump

is constructed either with one or two blades. There is naturally no difference in the mode of operation in the two types, but the doubled-bladed pumps give a more regular delivery. The 1¼ in. single-bladed pump has a cylinder 4 in. in diameter, and when running at 200 r.p.m. will deliver 2,400 gallons an hour. The weight in gun-metal is 22 lbs. The double-bladed pump is built in three standard sizes, of which the largest has a 6-in. cylinder and a 3½-in. diam. outlet. This pump will deliver 12,000 gallons per hour when running at 400 r.p.m. Kitson-Utley pumps are constructed in gun-metal, cast-iron or acid-resisting metals, and are being used for pumping petrol, crude oil, molasses, tar, paper pulp, margarine, acids, etc. When the liquid being dealt with contains grit or sediment likely to cause erosion, the ends of the blades are fitted with leather, rubber, fibre or other soft material, which sweeps the grit round the cylinder without doing any damage. The pumps can be used as vacuum pumps or as blowers, and with a single-blade pump, run at 750 r.p.m., a vacuum of 29 in. has been reached. The smaller sizes of pump are suitable for hand operation, as indicated in the single-bladed pumps shown in Figs. 1 and 3 to 7. The larger sizes, of which a double-bladed example is shown in Figs. 2 and 8, are arranged to be fitted with a driving pulley. In single-bladed pumps, the inlet and exhaust passages are placed together at one side of the casing. In two-bladed pumps they are at opposite sides. This arrangement follows naturally from the action of the blades.

CALCUTTA WATER WORKS.

In 1920, Mr. R. St. George Moore, M.Inst.C.E., was retained by the Corporation of Calcutta to report on the Water Supply of Calcutta and suggest measures for its improvement. The existing supply consisted of 49,000,000 gallons of filtered water and 30,000,000 gallons unfiltered. The filtered supply was pumped from the River Hooghly at Pulta, about 12 miles up the river from Calcutta, submitted to slow sand filtration, pumped to Calcutta and re-pumped for distribution. The unfiltered water was pumped from the River Hooghly opposite the City into the distributing pipes direct. Owing to there having been no census later than 1911 the figures for the 1920 population were not available, but they were estimated at 947,000 for the year 1921 and for the year 1941, 1,056,000, exclusive of the suburbs. Mr. Moore reported in favour of giving 80 gallons per head per day of filtered water and doing away with the supply of unfiltered water, making, with allowances for the suburbs, 94,000,000 gallons per day, the whole of the filtered water being supplied by increasing the works at Pulta. This would entail new machinery at Pulta, large pipes from Pulta to Tallah and new pumping machinery at Tallah; re-arranging the distributing pipes so that Calcutta proper was divided into four zones and the suburbs into three zones. A special pipe would deliver from the main pumping station at Tallah to the centre of each zone so that at all portions of the town the water would be delivered in proportion to the number of inhabitants in the zone.

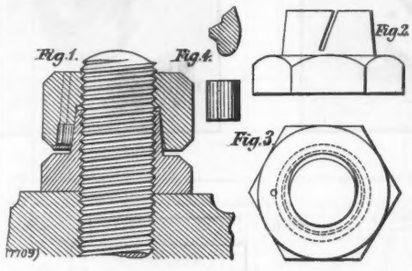
The proposals to give 80 gallons per head per day, and to do away with the unfiltered water supply led to lengthy discussions in the corporation. At one time the feeling in the corporation was that 80 gallons per head per day was not a sufficient allowance for a Hindoo population, and a supply of 100 gallons per head per day found a number of advocates. The question of doing away with the unfiltered supply also roused considerable discussion. One party considered that the expense of filtering all the water for street watering, fire and sanitary purposes was an unnecessary expense. The other party, headed largely by the doctors, was against putting unfiltered water on to the streets and allowing unfiltered water to run down the channels beside the roads, as it was impossible to prevent the natives washing and even drinking this unfiltered water.

It was eventually decided to increase the filtered water to 70,000,000 gallons per day and the unfiltered water to 40,000,000 gallons per day; the general principles of the filtered supply to be in accordance with Mr. Moore's report and the unfiltered water pumping stations to be rebuilt and enlarged. Instructions were given to Messrs. St. George-Moore and La Trobe-Bateman in August, 1921, to prepare the designs for the works.

Contracts have been let in England for about 30 miles of riveted steel pipes, weighing about 14,000 tons and varying in size from 5 ft. diameter to 33 in. diameter, and trenches for the piping to the Cleveland Bridge and Engineering Company, Limited. The Pulta and Tallah pumping machinery for 9,000,000 gallons per hour are to be carried out by Messrs. C. A. Parsons, Babcock and Wilcox, and Mather and Platt. The orders placed in India are for additional filter beds for 35,000,000 gallons per day, and an additional service reservoir at Tallah for 8,000,000 gallons. Future contracts are to be let for additional sedimentation tanks for 140,000,000 gallons, suction pipe intake and jetty at Pulta, pipe bridge across the Circular Canal at Barrackpore-road, Mullick Ghat and Watgunge unfiltered water pumping stations.

LOCK-NUT FOR RESISTING HEAVY VIBRATIONS.

We illustrate below a lock-nut devised and patented by Mr. F. J. Tinker, of 34, Iron Mill-lane, Crayford, which is stated to have proved exceptionally satisfactory in service under very trying conditions. As shown in Fig. 1, the lower nut is turned to a cone at its upper end, and this cone is split as indicated in Fig. 2. The upper nut has a corresponding conical recess, and when screwed home tightens up the split cone firmly on to the bolt. Unlocking is prevented by a friction pawl let into a recess formed in the upper nut, as indicated to the left in Fig. 1. This pawl which is shown to a larger scale in Fig. 4, is formed so that



it allows the two conical surfaces to move freely over each other during the process of screwing up, but locks them together against any relative rotation in the opposite direction, and thus effectually prevents "slacking back." The nut can nevertheless be easily unscrewed when required. To this end a hole is drilled from the top face of the upper nut into the recess for the pawl, as is indicated in Figs. 1 and 3. By driving a pin down through this hole the pawl is forced into the "free" position, and the upper nut can then be removed in the ordinary way. Mr. Tinker states that these nuts have been used on a light helve hammer forging gun barrels, and were still tight after a fortnight's continuous service, in which he estimates that some 5,000,000 blows were struck. The nuts previously used, he states, required tightening every 20 minutes and had to be completely replaced every 4 hours or 5 hours.

EXPLOSIONS IN LIQUID AIR RECTIFICATION PLANT.

The paper on "Explosions in Liquid Air Rectification Plant," which Dr. E. Fyleman, F.I.C., read before the Society of Chemical Industry recently, dealt with the erratic explosions occurring in the liquid oxygen baths which are situated at the bottom of the rectifying columns. The explosions are not infrequent, and they are of sufficient violence to make the adoption of special precautions advisable. Thus the liquid baths are sometimes placed in deep pits in order to reduce personal danger, though material damage would not be prevented by these means. The explosions are generally ascribed to acetylene which in some way finds its way into the apparatus, and near calcium carbide works and cyanamide works contamination of the atmosphere and of the intake air of liquefiers is not improbable, and has indeed been observed. Intake conduits of very great lengths have accordingly been adopted for liquid air plants situated in the neighbourhood of carbide and cyanamide works, as Dr. Harker pointed out during the discussion. But acetylene contamination did not seem to account for all the accidents, and Mr. K. S. Murray, of the British Oxygen Company, had asked Dr. Fyleman to investigate the matter. Mr. Murray referred to the question during the recent discussion on the "Generation and Utilisation of Cold," by the Faraday Society (ENGINEERING, October 20, last, page 509); but he did not give particulars on that occasion.

Dr. Fyleman first considered the possibility that the small amount of organic matter, which is always present in air and oxygen, even when liquefied, might be responsible. Liquid oxygen did leave a greasy organic deposit on evaporation, he observed; but it was not explosive. He then investigated the action of air and of oxygen on heavy lubricating oils, both at ordinary pressure and at a pressure of 30 atmospheres, such as is used in the compressors of liquefiers. In the reaction between oxygen and oil acetylene was produced at 315 deg. C. (600 deg. F.), and small explosions occurred in the small-scale tests, in which the acetylene formed was absorbed by silver nitrate; a silver acetylide is then produced which detonates on drying. Air did not yield any explosive compound with oil, even at 440 deg. C. (825 deg. F.), as long as the air pressure was not raised. Compressed to 30 atmospheres, however, the air likewise gave explosions at 315 deg. C. The character of the oil had little effect on the temperature at which the explosion occurred; with olive oil the explosion would set in at 320 deg. C. (608 deg. F.), with paraffin wax at 360 deg. C. (680 deg. F.). In contact with liquid oxygen acetylene solidifies, and any acetylene formed in the liquid accumulates in it and floats on the liquid. How the mixture of solid acetylene and liquid oxygen came to detonate, was, Dr. Fyleman stated, not yet determined. The floating mass of crystals was flocculent, and nothing happened when the solid and liquid oxygen were stirred in a copper beaker, not even in the presence of charcoal, turpentine or red lead. But a weight of iron falling into a compact mass of acetylene mixed with sand and moistened with liquid oxygen finally caused detonation.

Dr. Fyleman suggested that electric sparks might have a share in the explosion, in the separator of a liquefying apparatus; explosions seemed to occur by preference when a valve had just been opened and liquid was allowed to escape. As a result of the investigation the British Oxygen Company had found that they could avoid these explosions by keeping the temperature of the compressors, as measured by thermometers close to the valve seatings, below 300 deg. F., and by banishing all acetylene or carbide from the neighbourhood of the plant. Dr. Fyleman also stated that a very active absorbent for acetylene vapours could be obtained by hydrating plaster of Paris with an alkaline solution of potassium permanganate activated by the addition of a little silver nitrate. The problems are of interest to engineers, and not only in connection with the liquid gas industry. In such plants oils of high flash points should alone be used, in the compressors which should be kept cool. That practice would also avoid carbon deposition near the valves of the compressors of Diesel engines. Various other points were referred to during the discussion, among them, explosions of air compressors in mines and the substitution of steel coils for copper coils, steel being less liable than copper to form explosive acetylene compounds.

Optical Methods in Research Laboratories.—For some years Messrs. Adam Hilger, Limited, of 75a, Camden-road, N.W.1, have been issuing a series of books, compiled by men of scientific standing, for the aid of workers making use of the optical instruments in which the firm excels. The latest publication of this series, a second edition of "*Optical Methods in Control and Research Laboratories*" (price 1s. 8d. post free, limp cloth) is a very welcome addition to this literature, and will be appreciated as a guide to the selection and application of apparatus for the study of spectrum analysis, absorption spectra, refractometry and polarimetry. The compilers are Dr. J. W. Goldsmith, Dr. S. Judd Lewis and Mr. F. Twyman, head of the firm. The volume of 56 pages, royal octavo, illustrated by three photographic plates and by diagrams, forms a continuation of Dr. L. Silberstein's pamphlet on "Refractive Index, Absorption Wave-Length and Rotatory Power in Relation to Molecular Structure," previously published by the firm. The book is a scientific treatise and bears very little resemblance to a trade publication. Detailed descriptions of the instruments or of their construction are not given as there are ample references to sources of information on these points. The book surveys the most recent literature on the subject in question, with special regard to established and new applications.

Standardisation in Swedish Industry.—The commission for introducing standardisation in Swedish industry has just commenced its work. It is a highly representative body; the chairman is appointed by the King, and the Naval Ministry, the Traffic Ministry, the Department for Commerce, the Swedish Industrial Union, the Academy of Engineering Science, the Swedish Technological Union, the Jernkontoret, the Paper Industries Union, etc., are represented, in several instances by more than one expert. Standardisation is looked upon as a vital condition for the industrial production of Sweden, and the question is very much to the fore in most industrial countries. The endeavours to introduce it in Sweden will, it is fully anticipated, meet a fairly determined opposition in more industries than one, but this will not act as a deterrent, and it is not the first time that the introduction of general rules within industrial production has been strongly opposed. Looking back upon the past, it is difficult to understand the reason of such opposition. It is not proposed to carry standardisation to any undue length, but the secretary of the Commission maintains that it is badly needed in Sweden, a fact which has for some time been patent to many who are familiar with Swedish industry. He maintains, further, that it is not an unusual thing to find articles for which the present cost of production can be reduced by 10 per cent. In order to be in a situation to compete, Sweden, like other industrial countries, must, as soon as possible, avail itself of the advantages accruing from general industrial standardisation, hence the appointment of this important Commission.

SOME MECHANICAL PROBLEMS IN THE RUBBER INDUSTRY.*

By H. C. YOUNG, Associate Member.

(*Continued from page* 251.)

Standard Mills.—The trouble of dust from powders which choke the oil holes, and cause hot bearings is a serious one. The batch of rubber and ingredients to be mixed with it, is weighed on to the mill, and weighed again when taken off, and must be within a given tolerance. It is important that nothing should lodge between the neck of the rolls and the guide plates. If a few ounces of each batch accumulate, this, when of sufficient mass, is gripped by the rolls, and pushed into the tray, the result being that the particular batch is scrapped on account of excess weight. It is imperative that the design of the mill should be such as to keep the weight of the batch constant.

Labour-saving has been attempted by the use of drug sifting feeder apron gear and enclosed milling. The apron gear is much used in some mixing mill plants in America. There is great need of efficient hoods to take away the dust caused by powdering. The slot over the back roll is very effective, but for light powders such as gas black, does not fully meet the case.

Bearings.—In mixing mill design, owing to the excessive pressure on the bearings, and the fact that, when the rolls are empty, they float away from the usual load position and return with a thump on load, lubrication is an important factor, and the metal linings for the bearings need the closest attention. If the metal be too soft, it will roll out as much as ¾ in. endwise. Under the load the bearing heats up, but this heat is carried away by the roll cooling water. Even then trouble arises from hot bearings, and it is questionable whether a special housing giving a clean face for the production, and housing the bearings and wheels, would not pay. The rolls need only be considered even loaded, and need not be made stiff enough to accommodate the peak loads, as the breaking bush should do this. General overload is safeguarded against by the motor trip. Grinding of the rolls is prevented partly by a wedge placed between the bearings, but considerable damage to the rolls can be caused unless ample adjustment is allowed on the guide plates, as with most roll bearings there is no means of taking up wear.

End Wheels.—The end wheels should be designed to have their centres moved over a range of ⅛ in., and unless ample strength is provided, the teeth fail. Nearly all cases of roll neck breakages are caused through the end-wheel teeth breaking first. In several mills end wheels of steel with double helical teeth (machine cut) were discarded because of excessive ridging on the pitch line, in addition to rapid wear of teeth. In their place, ordinary cast-iron gears with straight teeth were fitted, and gave much more satisfactory service. No figures are available showing the horse-power taken by the back roll, but undoubtedly this is directly proportional to friction ratio. If the breaking bush remote from the end wheel breaks, the end wheel will jam, because more rubber tries to pass the nip, and the roll opens right out at the end when the bush fails. This movement should be limited by placing stops in the cheek front, or on the side of the bearing. On breaking down rolls on which the cold rubber is first treated, cast-iron double-helical gears fail every time a bush breaks; also heavy grooving on the pitch line is general.

Safety Bushes.—The standard method, as in washing machines, is to fit a bayonet flange bush, taking the adjusting screw, and reduced in section to break at a calculated load. The method is extremely crude. In the first place cast-iron varies largely in strength, and secondly the density of casting varies, the bushes often showing blow-holes. Practically all mills now installed have this type of bush. If cold rubber is fed on to a plain roll rubber mill, it is fairly certain that a bush will break. Overloading a rubber mill may be disastrous and must be guarded against. Attempts have been made to reduce the cost of the bush replacement by applying discs, bushes, and by special screw lining, but these have the fault of failing under load. The ideal bush is one that does not move until the fixed pressure point is reached. Hydraulic systems have been successfully applied, but their cost is high.

Roll Adjustment.—Little or no attempt has been made to arrange for parallel adjustment of the rolls, and considerable damage can be caused through uneven roll setting apart from the inconsistent working of the rubber. Plantation crêpeing rolls have a parallel motion gear fitted, which, when once set, can be locked. Most existing mixing plants have not even an efficient indicator showing the position of the roll, and some device is necessary which will indicate clearly the roll position and will allow for wear of bearings.

Roll Faces.—Chilled iron has generally been used for mixing mill rolls, but this is not necessary. A good grey cast-iron will not only reduce the weight of the roll, but will permit much more efficient roll cooling. Rolls in chilled cast-iron 4½ in. thick, which have broken under load, have been safely replaced by rolls 3½ in. thick in cast-iron, resulting in a considerable saving of water. The latest practice is to use 2-in. steel rolls. These were installed first by a British rubber company, and have resulted in lower temperature of mix, giving at the same time 60 per cent. saving in the water consumption. The only objection to the steel rolls is that they are scratched by the mixers' knife in cutting off, but this is not a serious objection. Attempts have been made to obtain this saving by rolls having only a ½-in. steel shell, the cast-iron centre being cored to allow the cooling water to scrub the inside of the shell; but it was found impossible to keep the roll tight. Several patented types of roll have shown decided improvements, but do not seem to have been adopted. The water service of the roll is worthy of attention. The water is supplied to the roll through a special gland connection attached to a pipe feeding the water to the remote end of the roll from the supply. The water returns along the inside of the roll and is discharged through the same gland connection to a return water circuit. This method creates considerable difference in temperature on the roll. If the water could be fed straight through the mill roll, more even roll temperatures would be possible, hot spots would not be so pronounced and the bearings would receive more uniform cooling. It is questionable whether it would not be advisable to design the front roll specially, giving the necessary amount of clearance between the bearing and gear wheel to obtain this objective. Patents have been taken out recently in this country by American engineers for controlling automatically the temperature and the water supply. These are distinct steps forward.

Safety Stop.—If it is necessary to stop the machine

Fig. 15. TEN MINUTES MASTICATION TEST
500 B.H.P. MOTOR DRIVING FOUR 84-INCH MILLS. RUBBER MASTICATED FOR TEN MINUTES, THEN ALLOWED TO COOL FOR TWENTY-FOUR HOURS. THIS OPERATION WAS REPEATED FIVE TIMES.

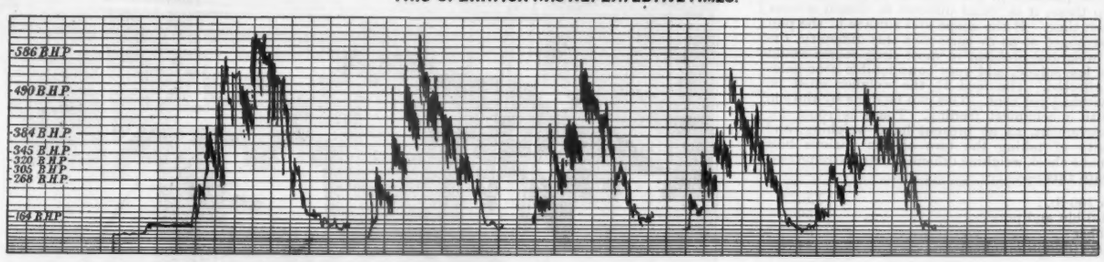


Fig. 16. SHOWING LOADING OF MILLS & DECREASE OF POWER AS RUBBER BECOMES MASTICATED, ALSO OPERATION OF BRAKE. SPEED ½ INCH - TEN MINUTES.

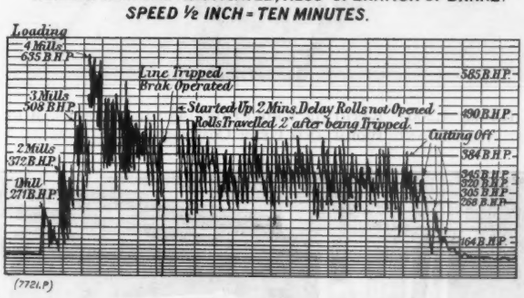


Fig. 17. TYPICAL MASTICATION LOAD.

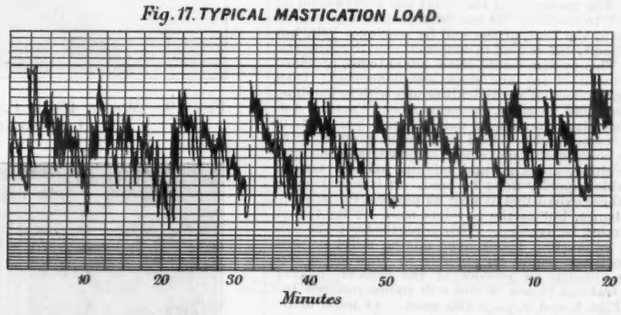


Fig. 18. TYPICAL POWER CHART. LINE OF FOUR 84-INCH MIXING MILLS.

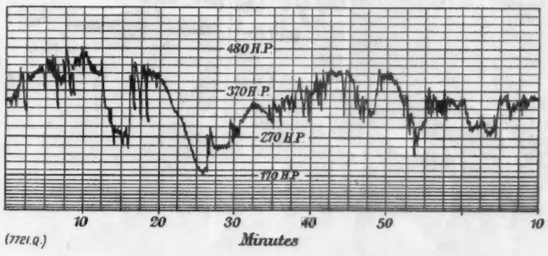


TABLE IV.—*Special Tests on Warming Mills.*

Size and Type of Mill.	Fast 60 In.		Slow 60 In.		Slow 48 In.	
Speed of rolls—	r.p.m.	ft.p.m.	r.p.m.	ft.p.m.	r.p.m.	ft.p.m.
Front	13·24	76·25	9·46	54·4	12·5	52·4
Back	19·87	114·4	13·17	75·6	17·77	74·4
Friction ratio ..	1·5 : 1		1·39 : 1		1·42 : 1	
Grade of rubber ..	Cures Hard	Cures Soft	Cures Hard	Cures Soft	Cures Hard	Cures Soft
Average weight batch, lb. ..	150	150	150	150	50	50
Rubber warmed per minute, lb. ..	300	40	200	28·6	60	11
Rubber warmed per square foot roll surface per min., lb.	10·4	1·39	6·95	0·99	3·58	0·59
Flow of water ..	23 gallons per minute		18 gallons per minute		10 gallons per minute	
Temperature of rubber	100 deg. C.	79 deg. C.	81·2 deg. C.	71 deg. C.	90 deg. C.	70 deg. C.

* Paper read before the Institute of Mechanical Engineers, on Friday, February 16, 1923.

instantly, this is done by a safety device. A wire running the whole length of the mill line, and within easy reach of a workman, operates a trip-out switch, which either cuts out the magnetic clutch or the electric motor, and allows the brake to operate. In addition, bars are fixed across the front of grinding and warming mills to enable workers to have some sort of support, if one hand, is caught, until the trip wire is touched. Operators' hands can be badly injured without going into the nip, by being gripped by the hot wedge of rubber, the finger nails, skin and flesh of the hands suffering.

Weighing and Transportation of Drugs.—The mill drug room is an important department, the drugs and powder requiring the most careful weighing. Some of the drugs weigh less than ¼ per cent. of the batch, and are a very much smaller percentage of the bulk. Most plants use zero shell weighers operated by hand. Attempts have been made to set up automatic weighers at each bin, which are so synchronised as to deliver a correct batch to the pan as it traverses the line of powder bins. A simple scheme has also been attempted for conveying the pan past each weighing station; as a pan passes under a weigher it is placed so as to catch the automatically weighed out drugs in proper sequence, the pan being check weighed by hand at the end of the run. Owing to the powders in use clinging to the scale and building up there, it is found difficult to obtain correct weights each time. If the shape and surface of the pan could be arranged so as to surmount this difficulty, the automatic weighing problem in most drug rooms would be more or less solved, and very considerable economies could be effected. The feed to the weigher must be constant within ¼ per cent. This can be done by the silo method with mechanical feeding. There is room for much improvement, as at present hand weighing, and the necessity of taking the tare of the various bins and pans make check weighing difficult. An extreme case will illustrate this :—

Batch 100 lb. :	Lb.
Metal bin and pots	150
Rubber	56
Drugs (five in number)	44

Tare = 60 per cent. of whole.

If it were possible to weigh out the drugs, and check-weigh without the various pots, more accuracy would be assured. The transport of the drugs has always been by hand truck to the mill. It has been proposed to convey the drugs to the back of the mill by conveyor belt, but this is difficult, unless used in conjunction with automatic mixers. This system would show advantages, provided a large output of any one stock was demanded. Dust control and collection are difficulties met with in handling drugs, the more so since, under a recent Factory Act, all rubber mixes containing more than 5 per cent. of lead-mix come under "lead and fume process." As there is a considerable movement of powders in the open when weighing, checking and mixing, exhaust fans of considerable capacity must be used. It is sound policy to have these exhausters as near as possible to the point of disturbance, but as the powders used are light, high velocity must be avoided. This is particularly the case with fan exhausting hoods over mixing mills, as with high velocity it would be possible to draw off a considerable quantity of powder at the time of mixing. The illustrations shown of the mill rooms indicate this clearly (Figs. 8 and 9, page 250 *ante*). As most of the powders used in the industry are, under favourable conditions, good conductors of electricity, it is well to have a pipe-ventilated type of motor, unless it can be housed outside the department. Air ducts should be arranged so that they can be cleaned out easily, and should not have sharp bends except for collection purposes.

Waste Powders.—In a mill, with these points not closely watched, as much as 3 per cent. waste powder can be created, but with care and attention to lay-out this can be reduced to ¼ per cent. or under, and, if the method of collecting be by vacuum even this waste may be converted to useful stock. It is for this reason that lineshafts and bearings are best clear of the floor, the bearings being hooded, to permit the dust to be salved.

Powders.—The powders used in rubber mixes should be dry and free from foreign matter, such as grit, splinter, sacking, paper, and the powder particles should be extremely fine. Although the powders may be purchased under specification, the rubber manufacturer would be unwise to use them direct from the bags or sacks as received, owing to dirt inclusion whilst packing, transporting and unpacking. About 50 or more powders differing in specific gravity, weight per cubic foot, fineness, &c., may have to be treated, and when providing conveyors, dryers, sieves and storage bins, the nature of each powder must be considered. In laying out the powder plant, the engineer will realise the necessity for conveying by means of bucket elevators, but in many cases it will be found more convenient to convey by means of worms. An engineering problem here presents itself as to the type of worm. Its speed and angle will have to be considered with each powder. Work has been done in connection with two distinct types of 6-in. worms, the crescent and the continuous, at varying speeds and set at different angles. For the lighter powders the continuous worm is the most suitable; in fact, the crescent worm is useless for the light bulky powders such as magnesia and carbon blacks. The crescent worm, however, is the better for heavy powders, such as lithophone, and for medium heavy powders such as zinc oxide, sulphur barytes, whiting, China clay, when it is necessary to convey through an angle of more than 30 deg.

Drying.—Several types of drying machines have been tried, the principal of which are :—

No. 1, Rotating Drum Type.—An efficient dryer when the walls are systematically cleared, but there is a tendency for the damp powder to cake on the walls and retard the drying.

No. 2, Steam-cased Worm-Conveyor Type.—This has not proved very efficient in practice.

No. 3, Rotating Steam-Heated Pipe Cage Type.—This machine has given the most satisfaction, for it is adaptable to all types of powders, and its speed and temperature can be readily adjusted to suit powders of varying moisture content.

On page 283 are given results obtained from a drier of No. 3 type. This machine has a capacity of 12·5 cub. ft., the steam-pipe cage acting as a paddle, being driven at 16 r.p.m. and heated by steam at 70 lb. steam pressure.

Sieving.—There are numerous standard sieving machines available such as those used in the flour-milling industry, the principal of which can be divided into three classes :—

Class I.—Shaking reciprocating sieves, often known as "dicky" sieves.

Class II.—Centrifugal sieves.

Class III.—Brushing sieves.

Type III is suitable for all powders and its output is good. It, however, is costly on maintenance, owing to the short life of the sieving cloth, which is due to the continual rubbing by the rotating brush. Considerable trouble is given with this class of sieve on account of the sudden bursting of the cloth, allowing the powder tailings to fall into the sieved powder.

Classes I and II have proved entirely satisfactory. The maintenance cost of the former type is exceptionally low, but it is not suitable for all powders. The centrifugal machine has proved satisfactory for all powders. The maintenance cost, however, is greater than that of the dicky sieve, and an additional disadvantage is the difficulty of removing the tailings completely. A usual practice is to place the dicky and centrifugal sieves in series, the usable tailing being run through a small grinding mill and returned by conveyor to the circuit. Output figures for a dicky sieve are given opposite.

Storage.—When providing storage bins the sizes required must not be calculated from the specific gravity of the powder. The specific gravity refers to each individual particle, and not to a mass of particles. It, therefore, is necessary to find by experiment the weight of a standard volume of massed powder. Tabulated figures on page 283 compare the weight per cubic foot, of massed powder with the true specific gravity. Square bins and taper "take aways" should be avoided; round bins are better. All bins, sieves, heaters, and conveyors must be connected to the exhaust dust collector, and elevators should be designed to avoid air

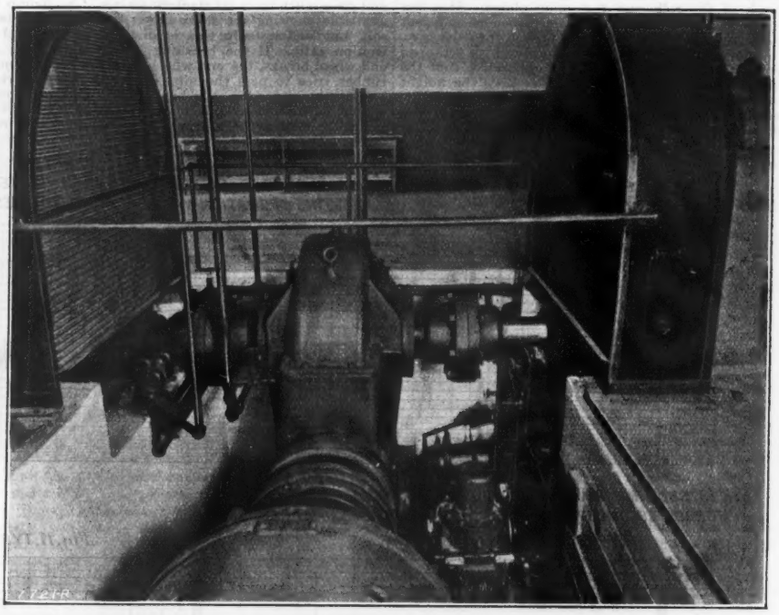


FIG. 19. MOTOR 400 H.P. R.P.M. 1,200. RATIO OF REDUCTION 14⅔ : 1. RUBBER MILL—LINE SHAFT. (CLEVELAND WORM AND GEAR COMPANY.)

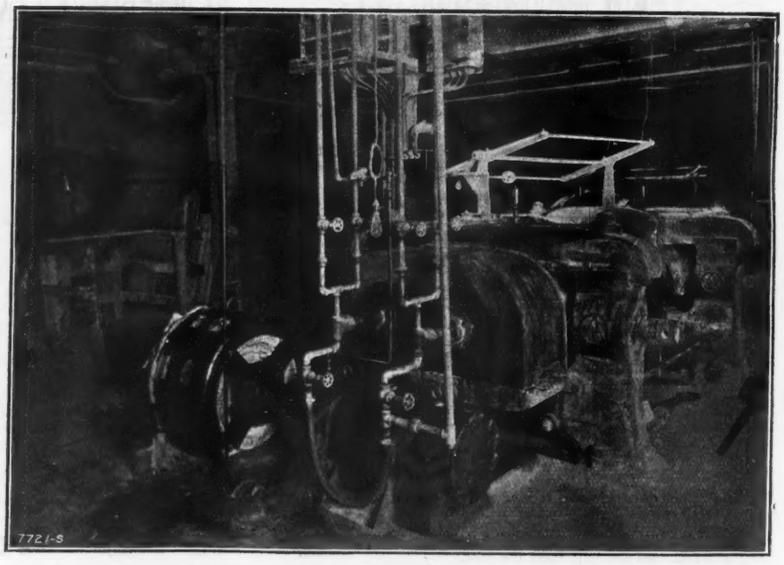


FIG. 20. MOTOR 100 H.P. R.P.M. 860. RATIO OF REDUCTION WORM DRIVE 13¼ : 1 RUBBER MILL—INDIVIDUAL DRIVE.

pump action and with minimum clearance. High-class rubber belts are necessary.

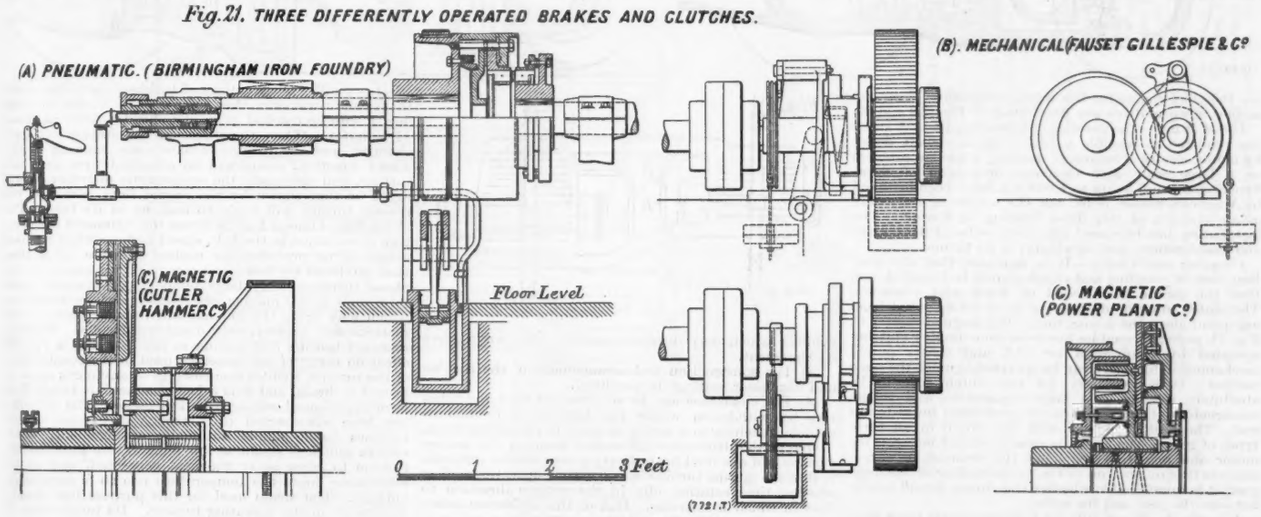
Washing, Warming, Masticating and Mixing Mill Drives.—Table V gives particulars of typical British, Continental and American mill practice. With regard to the type of motor (assuming that alternating current is being used), a selection may be made from the following: The standard slip-ring type induction motor, the "corrected" induction motor, that is, the induction motor fitted with a phase advancer or vibrator, the synchronous motor with damper windings for starting, and the synchronous induction motor. If the power factor is not very important, and the first cost has to be kept down to the lowest point, the ordinary type of induction motor may be selected. If, however, the power factor is of considerable importance, as is often the case when power is purchased, one of the other types of motor mentioned may be adopted with advantage. Figs. 15 to 18, page 281, are reproductions of portions of power charts for mixing and masticating mills. The comparatively slow speed of the various milling operations makes the motor drive an important question of equipment. The back-line shaft speed in American practice does not exceed 120 r.p.m., and is as low as 56 r.p.m. in British and Continental mills. To keep the mill gears within reasonable dimensions, the average speed of the back shaft should be 75 r.p.m. This means there is a reduction of 6 or 7 to 1, from the motor speed somewhere in the region of 400 r.p.m. In this country 95 per cent. of the mill drives are of the gear-reduction type. The drive can, however, be accomplished by worm, chain, and in some cases by motor direct.

Very little attention has been paid to the line efficiency of the mill, and most firms installing plant have left it to the factory engineer or consulting engineer to suggest

TABLE V.—MILL PRACTICE.

Machine.	British.						Continental.						American.					
	Length of Roll.	Diam. Roll. Front.	Diam. Roll. Back.	Speed Roll, R.P.M. Front.	Speed Roll, R.P.M. Back.	Friction Ratio.	Length of Roll.	Diam. Roll. Front.	Diam. Roll. Back.	Speed Roll, R.P.M. Front.	Speed Roll, R.P.M. Back.	Friction Ratio.	Length of Roll.	Diam. Roll. Front.	Diam. Roll. Back.	Speed Roll, R.P.M. Front.	Speed Roll, R.P.M. Back.	Friction Ratio.
	in.	in.	in.				in.	in.	in.				in.	in.	in.			
Washing Breakers	24	15½	15½	15·4	22·6	1·47 : 1	35·4	15¾	15¾	11	17	1·545 : 1	30	16	16	28	30·8	1·1 : 1
	30	16	16	22·31	23·38	1·06 : 1	33·45	15½	15½	9	16	1·77 : 1	36	18	28·0	16·3	18·0	1·1 : 1
	30	16	16	11·2	16·9	1·5 : 1	—	—	—	—	—	—	—	—	—	—	—	—
Washers	30	16	16	14·8	17·3	1·65 : 1	35·4	15¾	15¾	14	17	1·21 : 1	44	18	16·0	26·1	39·19	1·5 : 1
	30	16	16	12·6	17·3	1·37 : 1	—	—	—	—	—	—	—	—	—	—	—	—
	30	16	16	22·17	24·28	1·09 : 1	—	—	—	—	—	—	—	—	—	—	—	—
Finishers	24	16	16	16·6	25·0	1·5 : 1	35·4	15¾	15¾	12	19	1·58 : 1	30	16	16·0	26·0	28·6	1·1 : 1
	30	16	16	12·6	17·3	1·37 : 1	—	—	—	—	—	—	44	18	16·0	31·3	39·19	1·25 : 1
	30	16	16	23·23	24·28	1·04 : 1	—	—	—	—	—	—	—	—	—	—	—	—
Masticating Mixing and Warming Mills.	36	16	16	13·9	24·3	1·76 : 1	33·46	15¾	15¾	9	16	1·77 : 1	—	—	—	—	—	—
	48	16	16	8·0	16·0	2 : 1	47·25	15¾	15¾	8	14	1·75 : 1	48	16	16·0	20·6	31·08	1·51
	48	16	16	19·6	21·6	1·1 : 1	—	—	—	—	—	—	—	—	—	—	—	—
	48	16	16	13·9	24·3	1·76 : 1	—	—	—	—	—	—	—	—	—	—	—	—
	54	18	18	9·0	16·0	1·78 : 1	—	—	—	—	—	—	—	—	—	—	—	—
	60	22	22	9·46	13·17	1·39 : 1	62·9	23·62	23·62	6	8	1·33 : 1	60	22⅛	20·0	15·6	26·0	1·66
	60	22	22	13·24	19·87	1·51 : 1	66·9	19·68	19·68	8	14	1·75 : 1	—	—	—	—	—	—
	84	22	26	11·49	14·48	1·5 : 1	68·89	19·68	19·68	8	14	1·75 : 1	84	24	24·0	14·4	20·17	1·4 : 1
	84	22	26	8·45	10·75	1·5 : 1	—	—	—	—	—	—	84	26	22·18	13·0	23·0	1·77: 1
	84	22	26	15·4	19·6	1·5 : 1	—	—	—	—	—	—	84	26	22·18	12·95	22·7	1·47 : 1

Fig. 21. THREE DIFFERENTLY OPERATED BRAKES AND CLUTCHES.


(A) PNEUMATIC. (BIRMINGHAM IRON FOUNDRY)
(B). MECHANICAL (FAUSET GILLESPIE & Cº
(C) MAGNETIC (CUTLER HAMMER Cº)
Floor Level
0 1 2 3 Feet
(C) MAGNETIC (POWER PLANT Cº)
(7721.T)

Drying.

Powder	Output per Hour.	Moisture. Before Drying.	Moisture. After Drying
	lb.		
Carbon black	1,800	2·4	1·0
		2·3	0·9
		2·29	0·8
Magnesium carbonate	1,700	1·31	0·02
		1·26	0·06
		0·41	Nil.

Sieving.

Description of Machine.	Powder.	Output.
		cwt. per hour.
Dicky sieve set at angle of 5 deg. covered with 15 sq. ft. of steel gauze of 40 mesh	Golden antimony	1
	Litharge	17
	Lime	11
	Sulphur	6
	Whiting	2
	French Chalk	8
	China clay	1¼

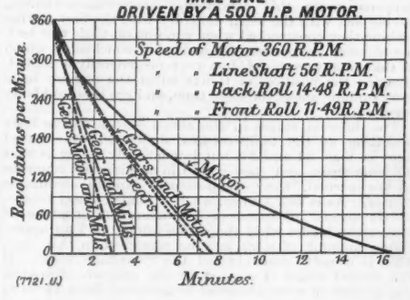
better equipment, whereas much might be done by suppliers themselves. Comparisons of warming mills are shown in Table IV, page 281.

Gear Reduction.—Because of the ratio necessary between front roll speed and motor speed, gear reduction requires the speed of the motor to be low; most gears supplied are double helical and leave much to be desired. In general, neglect and carelessness cannot be the cause, as the plant suppliers have helped in attempts to surmount the trouble.

If the efficiency of this type of reduction gear is good at the time of its installation, it must fall away very much as wear takes place. It would appear that the coarse pitch adopted to suit the heavy variable loads which take place, does not make for the even running of the gears. A great difference is shown with correct and incorrect lubricants. Of two sets of gears under observation, put into operation together, one with special lubricant, and the other with lubricant recommended by gear suppliers, early signs of wear were found in the latter case, while with the special lubricant the tool marks remained evident on gear teeth.

Chain Drives.—This form of drive is being installed to some extent in America, with, it is claimed, considerable success. If the speed of the chain is kept low it runs quietly, and has certainly no high standard to reach as far as noise is concerned. With special design of spring-loaded sprocket wheels, they are well able to accommodate the shocks set up by such loads as are common to rubber machinery drives. Ease of inspection, and definite means of taking up wear, are points in favour of chain drives.

Fig. 22. RETARDATION CURVE ON 84 INCH MIXING MILL LINE DRIVEN BY A 500 H.P. MOTOR.



Drugs.

Powder.	Specific Gravity.	Weight per Cubic Foot Measured	Approximate Weight per Cubic Foot Calculated from Specific Gravity	Actual / Calculated.
		lb.	lb.	
Zinc oxide	5·5–5·6	30	350	0·086
Lithophone	3·8–4·2	75	250	0·3
Barytes	4·5	51	282	0·182
Lamp black	1·8–1·9	8	118	0·068
Gas black	1·8–1·9	13	118	0·152
Light Cal. Mag.	3·1–3·7	9·5	218	0·436
Sulphur	2·0–2·1	56	126	0·445
Magnesium carbonate	2·3–2·4	10	150	0·067
Litharge	9·3–9·4	230	585	0·395
China clay	2·5	54	156	0·35
Lime	2·3–3·3	37	175	0·21
Whiting	2·8	50	175	0·285

Mill Drives.

—	Motor Speed.	Line Shaft.	H.P. Trans.	Efficiency.
Gear reduction	400	56	500	98½
Chain	435	85	500/1,000	98½
Worm	1,200	82	400	94
Motor direct	120	120	1,000	100

Worm Reductions.—Worm reduction drives have been adapted to calender and forcing machines, which take anything from 15 h.p. to 250 h.p.; but these loads are not subjected to sudden fluctuation as are those of mixing mills. The worm reduction has been installed where individual motor drives have been used for mixing mills. This reduction is in operation also on a battery of mills where the motor is placed midway on the line. Quietness, compactness and the use of high-speed motors

METROPOLITAN-VICKERS RATEAU MARINE TURBINE.

Fig. 23.

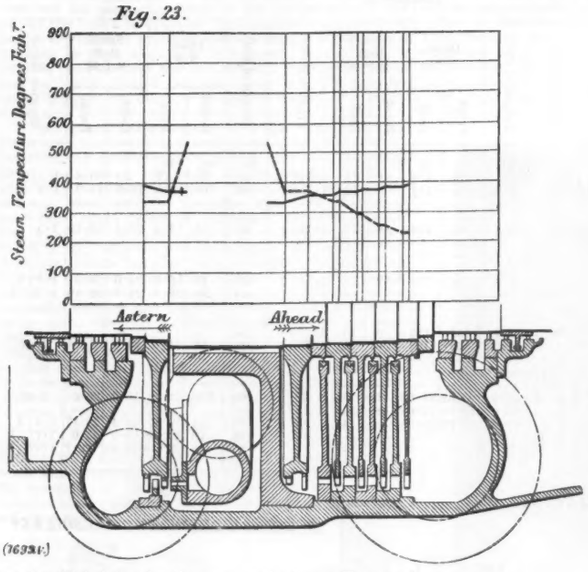
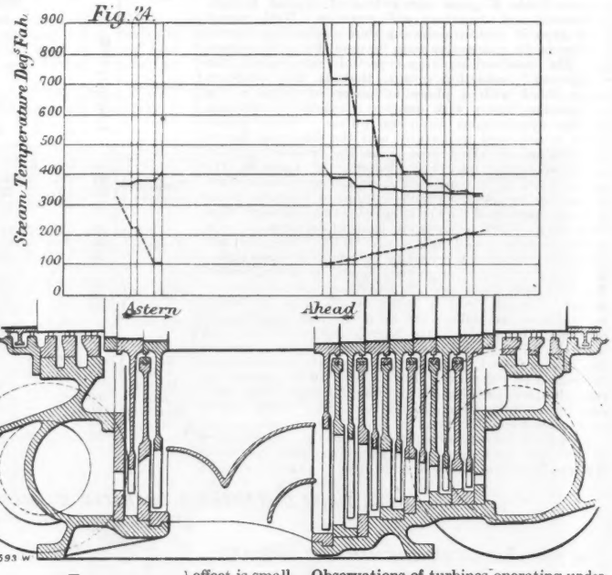


Fig. 24.



are the chief claims for the worm reduction. Two examples of worm drive are illustrated in Figs. 19 and 20.

Direct Drive.—The practice of increasing the mill speed has rendered it possible to drive the line-shaft direct by motor, electrical engineers meeting a similar problem on a large scale with electrical propulsion of ships. Synchronous motors up to 1,000 h.p. have been installed in American rubber mills, but the author is not aware of an example of this drive existing in Europe. The installation has increased efficiency, reduced floor space and maintenance, and simplicity, in its favour.

Coupling and Clutch.—It is desirable that the very best form of coupling and clutch should be installed, and that the motor be relieved of shock and vibration. The clutch must be designed so as to be operated from any point along the mixing line. The magnetic clutch C, Fig. 21, page 283, enables this to be done simply; clutches operated by compressed air (A), and others purely mechanical in form (B), can be operated in much the same manner. It is necessary for the clutch gear to be absolutely reliable, and large dimensions and robust construction of small details are good steps towards this end. The brake operates with the clutch in all three types of gear. The clutch is usually placed between the motor and reduction gear, but the retardation curves indicate that on account of the flywheel effect of the large gear, it is questionable whether the clutch should not be between the gear and the mills.

Line Shaft.—Practically all mill line shafts have ring-oiled bearings, but it would be economical to install roller or ball bearings and arrange a continuous bed, if necessary, for this purpose. The retardation curves (Fig. 22, page 283) give some idea of the possibilities of equipping with roller or ball bearings. A few rubber mill drives have had flywheels installed. With induction motors the percentage of slip must be arranged for the flywheel to be effective. The recording charts of a mixing line give some indication as to the possible usefulness of flywheel application.

(*To be continued.*)

METROPOLITAN-VICKERS RATEAU MARINE TURBINE.*

By H. L. GUY and P. L. JONES.

(*Concluded from page 222.*)

In all Metropolitan-Vickers turbines, the condenser is placed immediately below the exhaust, and is carried by the low pressure cylinder. Considerable importance is attached to this, and the design of the turbine has been largely determined by it. Some of the advantages associated with this arrangement are as follows:—

(1) An appreciably higher vacuum can be obtained behind the last row of blades as compared with those designs in which the condenser is connected to the turbine by even short pipes, particularly if these pipes take the form of bends.

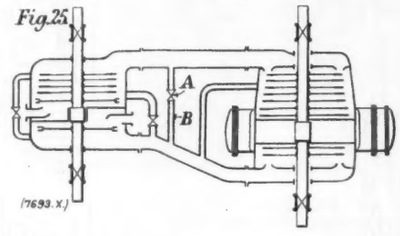
(2) The turbine is self draining. The problem of draining a turbine with a top exhaust or with an exhaust in such a position that the lowest point in the flange leaving the turbine is above the bottom of the cylinder, is an exceedingly difficult one, and the authors have not met a solution which is certain in its operation. The troubles which can, and do, arise from accumulations of water in a turbine cylinder are manifold.

(3) The condenser is free to expand. In alternative arrangement the thrust which can result from the absence of free expansion of the turbine cylinder, condenser and connecting pipes can throw loads on to the turbine cylinder which may distort it and in other ways affect its alignment.

(4) The construction and arrangement of the turbine and condenser seatings is simplified.

(5) The condenser can be so arranged that the tubes can be withdrawn under the high pressure turbine cylinder resulting in a saving of space in the engine room.

Fig. 25.



One of the distinctive differences between the marine turbine and one used for ordinary power station purposes is that the marine turbine is at one time operating and at another time rotating idly in the reverse direction to that in which it operates. Out of this difference arises a very serious difficulty, which is naturally peculiar to marine turbines, and as a result it has long been recognised that reversing may be a dangerous condition. There is a good deal of misconception as to what really happens under this condition. Metropolitan-Vickers, having met with the usual difficulty with the first marine turbine they constructed when running on their test bed, investigated the matter, and arrived at conclusions which at that time were novel, but are now generally accepted. Imagine the position of things when the engines have been running ahead for some time, and are then suddenly reversed.

The different stages in the ahead portions have been operating at the temperatures shown in the dotted lines in Figs. 23 and 24, but immediately steam is shut off from them and they rotate in a direction opposite to the normal, their temperatures rapidly commence to rise. As is well known, when a bladed wheel rotates in its normal direction in a stagnant atmosphere of steam, the blades whirl the steam about, and an appreciable amount of work can be absorbed in this way. This is usually denominated the "windage loss." If the bladed wheel is rotated in the opposite direction, the amount of work absorbed is increased from $1\frac{1}{2}$ to $4\frac{1}{2}$ times, the exact amount depending on the nearness of the walls of the chamber in which the blades rotate to the blade itself.

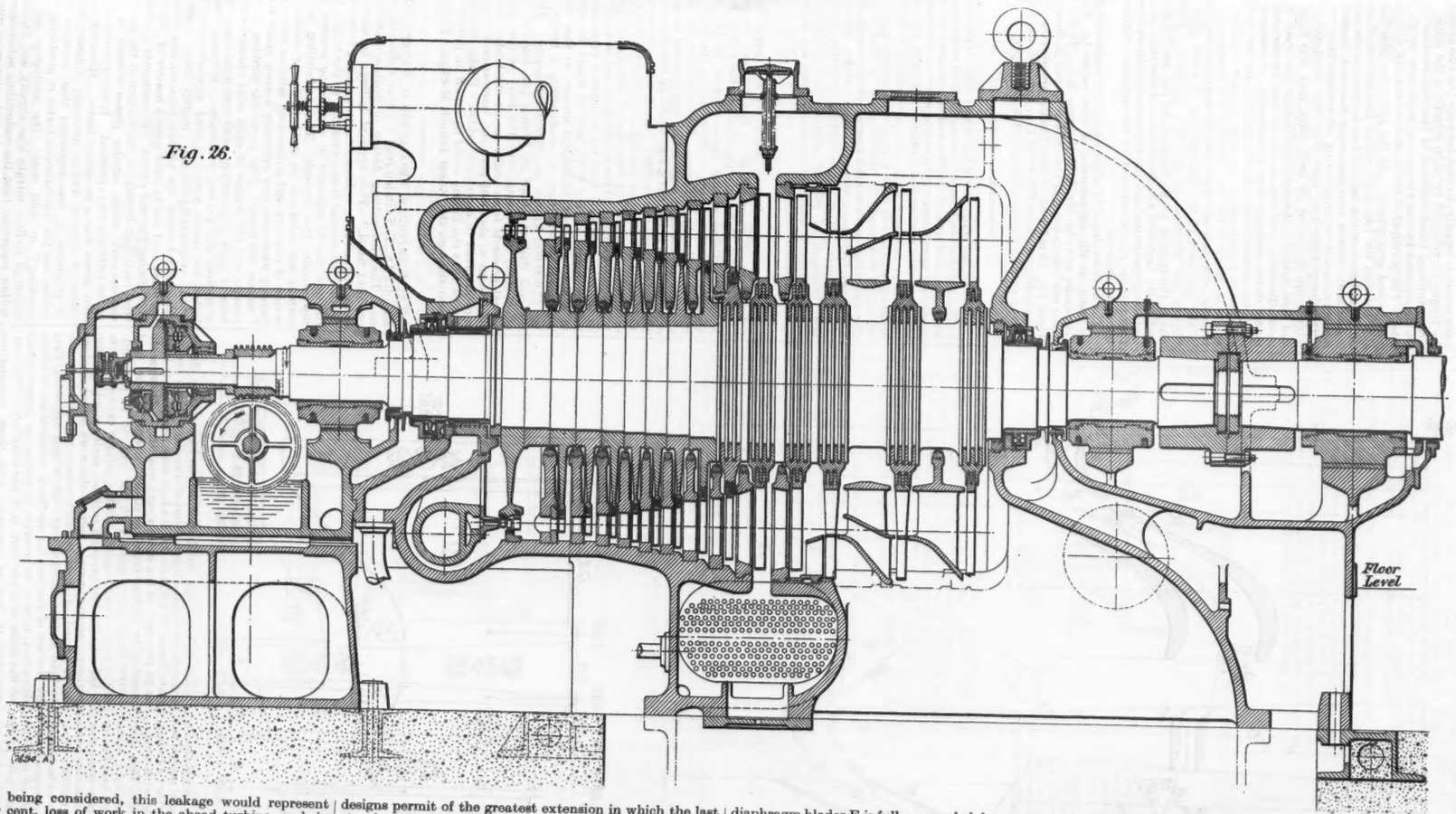
In the case of a typical 3,000 h.p. marine turbine rotating at 3,000 revolutions per minute, exhausting into 28-in. vacuum, approximately 50 b.h.p. is absorbed by the windage in the idle ahead turbine when running astern. The quantity of steam trapped in the cylinders is approximately 0·07 lbs. The temperature of this quantity of steam would, therefore, be raised at the rate of 1,000 deg. F. per second, provided no heat were radiated from the casing, and no steam is leaking into the idle turbine. The small amount of leakage steam which passes normally into the idle ahead turbine tends to limit the maximum temperature which can be reached. In the normal case being considered, the maximum amount which may leak into the cylinder in this way is of the order of 0·07 lbs. per second, so that the limit of temperature fixed in this way should be approximately 1,000 deg. F. Heat is, of course, also radiated from the casing which has the effect of reducing the maximum temperature obtained, but this effect is small. Observations of turbines operating under these conditions show that temperatures of 800 to 1,000 deg. F. can be reached in an idle ahead turbine in about 15 minutes. When the direction of rotation is again changed, and the turbine is once more running in the ahead direction, steam will be admitted to a very hot turbine, and ultimately the temperature distribution will again be that shown by the dotted lines, but now the reverse turbine will begin to heat up in its turn. The chain dotted line in Fig. 24 shows the estimated temperature distribution in the L.P. ahead turbine when running astern, if no provision for cooling is made other than that produced by leakage steam from the astern to the ahead turbine. Very large temperature changes which take place in this manner can result in serious distortion, which may bring the moving and rotating parts of the machine into contact, with disastrous results. Further, repeated heating and cooling in this way has a very ill effect on many of the materials used in the construction of the turbine, such as iron castings or any parts made of bronze or brass, and it is a fact that serious trouble has been experienced arising from this cause. The difficulty has been surmounted in Metropolitan-Vickers marine turbines by a simple automatic arrangement, which admits sufficient steam at low temperature into the idle turbine to carry away the heat generated, and at the same time limits the temperature rise to a permissible amount. The steam used for this purpose has already done work in the operating turbine. Its temperature is therefore low, and as it has performed work before it is used for cooling, the loss in efficiency can be reduced to very small proportions. The full lines in Figs. 23 and 24 show the estimated temperature distribution in the idle elements when provision is made for cooling these elements in the manner adopted by the Metropolitan-Vickers Company. In Fig. 25 this cooling arrangement is shown in a typical case. Steam is taken from the astern turbine after it has performed work in the high pressure section, and passes through the non-return valve A, which opens under the difference of pressure between the operative and the idle stages of the turbine connected by the pipe B. Cooling arrangements of this type have been fitted to all Metropolitan-Vickers marine turbines, and no difficulties have been experienced in operation through rapid or continual reversal, although the trouble which this device guards against is now very generally recognised as being the cause of many of the mysterious accidents which have occurred in marine turbines.

It may be suggested that the limiting temperature could be reduced to reasonable proportions by increasing the quantity of leakage steam. Unfortunately, the amount of steam which leaks from the ahead turbine into the astern turbine when the former is operating is approximately three times as great as that which flows from the astern turbine to the ahead turbine when running in the reverse direction. On the other hand, the amount of heat generated in the ahead turbine when running idle is from three to four times as much as that of the astern turbine running idle at the same speed. Thus, if the leakage is increased sufficiently to reduce the final temperature in the idle ahead turbine to safe limits, three times this amount of steam will leak from the ahead turbine to the astern turbine when the former is operating, thus resulting in a permanent loss in efficiency of considerable amount. Thus, supposing the leakage across the dividing diaphragm is to be sufficient to ensure that the maximum temperature in the ahead turbine, when running idle, will not be greater than 500 deg. F., the quantity of leakage steam required for this purpose will be approximately 0·22 lbs./second. Hence, when the ahead turbine is operating the leakage steam from the ahead turbine to the astern turbine will be approximately 0·65 lbs./second. However, in the case of the 3,000 s.h.p.

* Paper read before the Society of Naval Architects of Japan, at Tokio, October, 1922.

METROPOLITAN-VICKERS RATEAU MARINE TURBINE.

Fig. 26.



turbine being considered, this leakage would represent 5·7 per cent. loss of work in the ahead turbine, and, in addition, the negative work performed by this leakage steam in the low pressure astern stages would be of the order of 1 per cent. It will, therefore, be seen that the total loss, which it should be observed is a permanent loss, would be approximately 6·5 per cent.

From the considerations effecting design which have just been reviewed, the balance of safety, and therefore reliability, obviously lies in constructing a turbine for a given duty with as small a mean diameter of the blades as possible, consistent with efficiency. As the output to be developed at a given number of revolutions per minute increases, the main difficulty lies in providing adequate area through the last row of blades. The difficulty lies in reconciling reasonable stresses in the blades with the desirability of keeping the losses represented by the kinetic energy of the steam leaving the last row of blades within permissible limits. If these two conditions are to be met the design at the exhaust end must be such that the longest permissible blade is used on the smallest possible diameter. Therefore those designs permit of the greatest extension in which the last step in expansion is performed in several rows of blades on several wheels. The most obvious development along this line is the double flow exhaust, but this is inflexible, in that the change in economic output is from 2 to 1 and 2 to 1 only. Further, in practical designs a number of stages are duplicated unnecessarily.

The "Baumann" multi-exhaust turbine was evolved to solve this problem, and this solution results in a system of turbine construction which is so flexible that it presents great manufacturing advantages. Figs. 26A and 26B, taken from Baumann's paper on "Large Steam Turbine Practice,"* illustrate the principle of this construction. The last stage of the normal turbine is replaced by the two diaphragms J and GE. The steam leaving what in the normal turbine is the last but one row of blades D, is split into two portions by the ring dividing the diaphragms into two rings, G and E. That portion of the steam passing through the outer ring of diaphragm blades E is fully expanded down to the exhaust pressure, and operates in the ring of blades F, which are of the normal impulse type. Moving blade HF, like the diaphragm GE in front of it, is divided into two rings of blades, H and F. That portion of the steam which passes through the inner ring of diaphragm blades G is expanded through a small drop of pressure only, and passes into the inner row of moving blades H. Here the steam is further expanded, the action being similar to that in reaction blades. Leaving the moving blade H, the steam is expanded right down to the exhaust pressure in diaphragm J, and operates on the moving blades K. It will be noticed in the figure that 58 per cent. of the total steam quantity passes through the moving blades K, while 42 per cent. passes through the blades F; thus, by the addition of one multi-exhaust stage the permissible output of the turbine is increased by over 70 per cent. by the addition of one diaphragm and wheel.

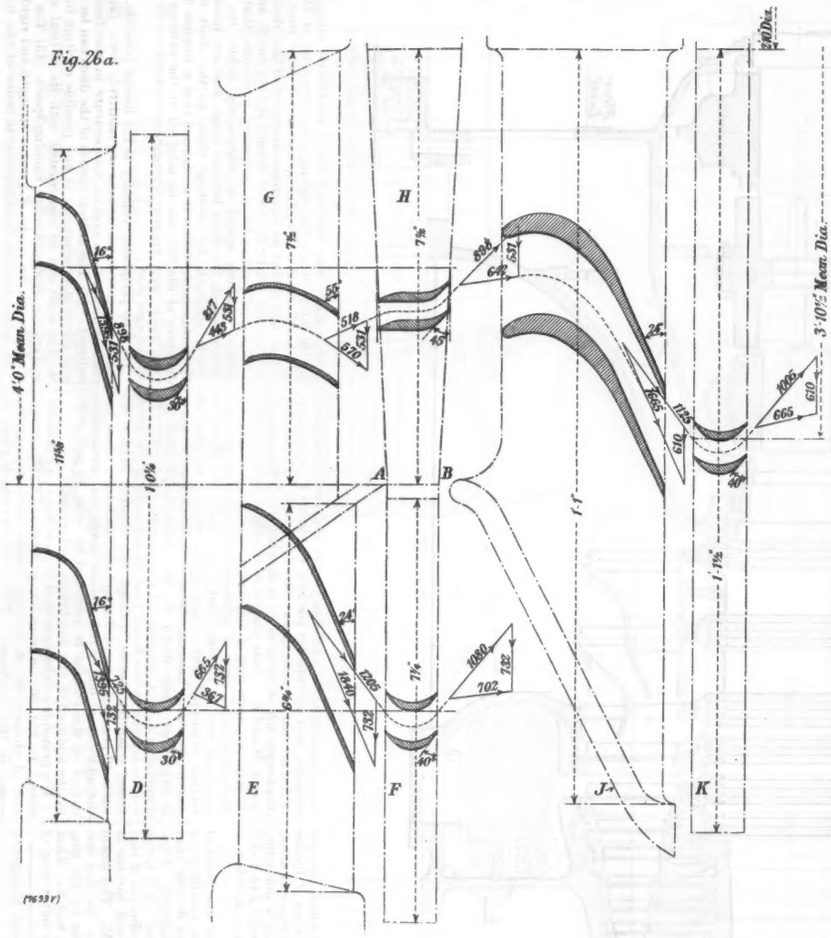
The principle can be extended to more than two exhaust rows. In Fig. 26 the principle is extended to the provision of three rows of moving blades, each exhausting steam to the condenser. This turbine, which runs at 3,000 r.p.m., was designed for a maximum output of 22,000 b.h.p. when exhausting into a vacuum of 28 in., and has been in successful operation for some time. It will be noted that as the mean diameter of the blades in this turbine relatively to its output is very small, and as a large shaft diameter is necessary to ensure that the normal running speed is adequately below its first critical speed, the discs become rings, and are made of ample strength by riveting them to the shaft itself. With this construction it is claimed that a smaller mean diameter of blading can be adopted at the exhaust end than with any known alternative method, with the advantages that:—

(1) The peripheral velocity is the lowest possible, and therefore centrifugal stresses are relatively low. (2) The risks resulting from uneven temperature in the discs are reduced. (3) The critical speeds of the discs can be kept well above the periodicity of any possible exciting forces. (4) The shaft can be constructed with its critical speed well above the maximum running speed. (5) The diaphragms can be made of greater strength and rigidity.

In many turbine installations, in spite of the higher

* Journal of the Institution of Electrical Engineers, Vol. 59, No. 302, June, 1921.

METROPOLITAN-VICKERS RATEAU MARINE TURBINE.



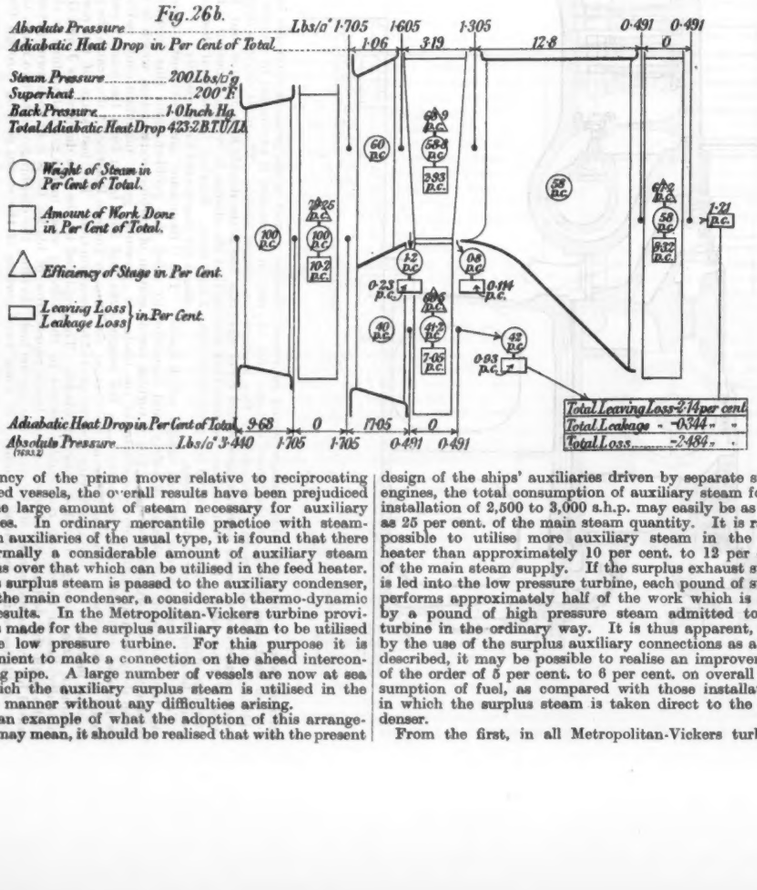


Fig. 26b.
Absolute Pressure ... Lbs/a² 1·705 1·605 1·305 0·491 0·491
Adiabatic Heat Drop in Per Cent of Total ... 1·06 3·19 12·8 0
Steam Pressure ... 200 Lbs/sq
Superheat ... 200° F.
Back Pressure ... 1·0 Inch Hg.
Total Adiabatic Heat Drop 423·2 B.T.U./Lb.
Weight of Steam in Per Cent of Total.
Amount of Work Done in Per Cent of Total.
Efficiency of Stage in Per Cent.
Leaving Loss / Leakage Loss in Per Cent.
Adiabatic Heat Drop in Per Cent of Total 3·68 0 1·705 1·705 0·491 0·491
Absolute Pressure Lbs/a² 3·440 1·705 1·705 0·491 0·491
Total Leaving Loss-2·14 per cent.
Total Leakage - 0·344 " "
Total Loss ... -2·484 " "

efficiency of the prime mover relative to reciprocating engined vessels, the overall results have been prejudiced by the large amount of steam necessary for auxiliary services. In ordinary mercantile practice with steam-driven auxiliaries of the usual type, it is found that there is normally a considerable amount of auxiliary steam surplus over that which can be utilised in the feed heater. If this surplus steam is passed to the auxiliary condenser, or to the main condenser, a considerable thermo-dynamic loss results. In the Metropolitan-Vickers turbine provision is made for the surplus auxiliary steam to be utilised in the low pressure turbine. For this purpose it is convenient to make a connection on the ahead interconnecting pipe. A large number of vessels are now at sea in which the auxiliary surplus steam is utilised in the above manner without any difficulties arising.

As an example of what the adoption of this arrangement may mean, it should be realised that with the present design of the ships' auxiliaries driven by separate steam engines, the total consumption of auxiliary steam for an installation of 2,500 to 3,000 s.h.p. may easily be as high as 25 per cent. of the main steam quantity. It is rarely possible to utilise more auxiliary steam in the feed heater than approximately 10 per cent. to 12 per cent. of the main steam supply. If the surplus exhaust steam is led into the low pressure turbine, each pound of steam performs approximately half of the work which is done by a pound of high pressure steam admitted to the turbine in the ordinary way. It is thus apparent, that by the use of the surplus auxiliary connections as above described, it may be possible to realise an improvement of the order of 5 per cent. to 6 per cent. on overall consumption of fuel, as compared with those installations in which the surplus steam is taken direct to the condenser.

From the first, in all Metropolitan-Vickers turbines the revolutions per minute of both high pressure and low pressure elements have been made the same. Owing to the nature of the design adopted it has been possible to do this without it being in any way necessary to compromise other elements in the design. In such a machine, if the power is equally divided between the two cylinders, the torque transmitted by each spindle is the same. As a consequence, those elements in the construction which are determined by the torque are duplicates on the two sides. The principal of these are the bearings, couplings, pinions and gear wheels. As the parts are interchangeable between the two sides, either the number of spares can be reduced, or the utility of such spares as are carried is doubled. It will be appreciated that such duplication has considerable manufacturing advantages also.

Resulting from the fact that the revolutions per minute are the same on both sides, and also from the fact that with the Metropolitan-Vickers construction the mean diameter need not be determined by the requirements of the ultimate step in expansion, the same mean diameter of the blades can be used in the low pressure cylinder as is desirable in the high pressure cylinder. In this way many of the disc forgings are common to high pressure cylinders and low pressure cylinders, and many of the jigs used in the manufacture of these discs and blading are common to the two cylinders. Further, due to the type of design adopted for the turbine glands, and to the fact that the revolutions of the high pressure and low pressure turbines are the same, it follows that the four turbine glands required for the complete turbine can be made identical.

The authors desire to acknowledge the assistance given to them in the preparation of this paper by Mr. K. Baumann, and also Mr. L. S. Robson, M.Sc. (Tech.), who made the calculations of the critical speeds of discs upon which Fig. 16 is based. Their thanks are also due to the Metropolitan-Vickers Electrical Co., Limited, for permission to publish the data contained in this paper.

SOCIETE ALSACIENNE DE CONSTRUCTIONS MECANIQUES.—This well-known French Company, which owns works at Mulhouse, Belfort and Graffenstaden, and have for many years past specialised in the construction of locomotives, boilers, steam engines and turbines, electrical and textile machinery, machine tools, &c., are issuing a quarterly bulletin, which will deal with their specialities and with technical and scientific questions of general interest. The first issue gives a brief history of the company and an illustrated description of their works, plant and manufactures. High-power turbo-alternators, plant for the utilisation of exhaust steam, electric rolling mill drives, designed and built by them, form the subject of special articles.

BRIDGING THE LITTLE BELT.—The *Danish Foreign Office Journal* reports that in the Finance Committee of the Danish Folketing the Minister for Public Works, M. M. N. Slebsager, has again referred to the urgent question of constructing a bridge across the Little Belt between Jutland and Funen. He stated that the railway engineering staff are engaged on the detailed work, and expressed the hope that a Bill would be introduced early. Estimates prepared in 1921 placed the cost at nearly 47,000,000 kroner, but the fall in prices that had since occurred permitted the reduction of that figure by about 10,000,000 kroner. If the bridge could not be constructed in the comparatively near future certain extensions and improvements in the ferry service would be essential, at a cost of about 10,000,000 kroner, so that the real additional expenditure of constructing a bridge would be 27,000,000 kroner or 28,000,000 kroner. Allowing for coal fuel at about 30 kroner per ton, the saving effected by dispensing with the ferry service, plus the actual proceeds from traffic across the bridge, would be equivalent to about 6½ per cent. interest on the expenditure involved in erecting a bridge. Under the Railway Act of 1918 the money could be raised on railway bonds issued through the Royal Danish Mortgage Bank.

THE BIRMINGHAM METALLURGICAL SOCIETY.—On the 8th ult., Dr. T. Swinden read a paper before this society on "The Embrittling Action of Sodium Salt Solution on Mild Steel." This type of failure, he stated, was quite distinct from ordinary rupture arising from stressing beyond the normal static strength, or the fatigue type of fracture due to repeated or alternating stresses causing slip within the crystals. The embrittling action of certain salt solutions on mild steel was similar to the action of mercury and ammonium salts on stressed brass causing what was now generally known under the term "season cracking." The particular problem under discussion was the failure of mild steel plates forming the base of large evaporating pans operating upon mixtures of sodium and potassium nitrates. Whereas these pans lasted for many years without any abnormal failure, when evaporating brine, trouble was immediately experienced when the nitrate solution was substituted for brine, and the failures were a matter of vital importance during the war period. Experiments showed that a steel plate laid loosely on the bottom of the pan was not deteriorated, whilst similar plates riveted in the pan in the ordinary way, cracked. It was obvious, therefore, that stress was a necessary factor. However, since the action of nitrates was so distinctly different from that of chlorides, it was suggested that selective chemical action was the fundamental factor in producing "season cracking" in mild steel. The analogous case of the action of sodium nitrate was already well known. The author suggested that the embrittling action was due to an absorption in a state of solid solution of nitrogen or oxides of nitrogen from the nitrate solution by the material forming the intercrystalline boundaries.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

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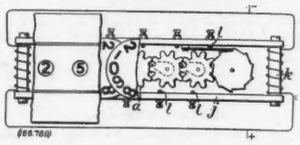
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

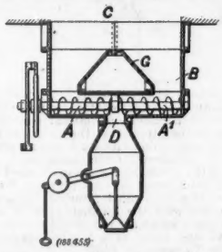
188,769. Evershed and Vignoles, Limited, Chiswick, London, and J. C. Needham, Chiswick, London. Magnetic Detents. (2 *Figs.*) August 16, 1921.—The invention relates to magnetic detents for revolution counters. The invention consists in the arrangement, in counting mechanism comprising a train of wheels *a*, *a* interconnected so that when a wheel of the series has completed a revolution the next wheel of the series



is rotated through a predetermined angle, of cogs, capable of being magnetised, on the wheels, two projections *l*, *l* arranged in proximity to diametrically-opposed cogs of each of the cogged wheels *a*, *a*, the projections also being capable of being magnetised, and a magnet *j*, *k* to magnetise the cogs and the projections so as to produce a magnetic detent effect. (*Accepted November* 29, 1922).

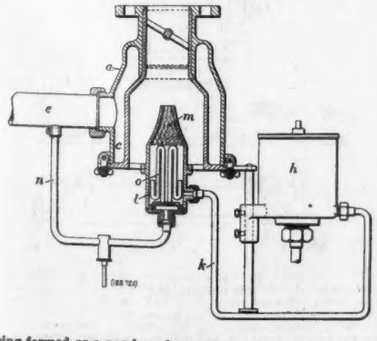
GAS ENGINES, PRODUCERS, HOLDERS, &c.

188,455. Woodall, Duckham and Jones (1920), Limited, and Sir A. McD. Duckham, London. Retort-Discharging Devices. (2 *Figs.*) September 16, 1921.—The invention relates to apparatus for discharging materials at the base of retorts. The evacuation of materials at the base of the retort is effected by means of a worm screw A, A1 accommodated in an elongated narrow trough B provided under the opening C in the base of the retort, which has a similar shape. The worm screw is



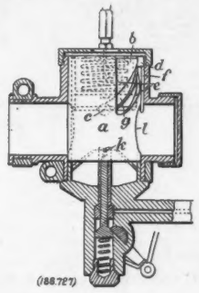
arranged to convey the material along this trough from each end to a central discharge opening D, the worm screw being centrally disposed in the trough under a fixed ridge plate or shedding device G which serves to direct the material towards the ends of the trough and also, in conjunction therewith, affords an effective support to the contents of the retort without any auxiliary movable support or grate. (*Sealed.*)

188,725. W. Pickard, Rochdale. Internal-Combustion Engines. (1 *Fig.*) July 16, 1921.—The invention relates to vaporisers for internal-combustion engines of the kind in which exhaust gas or a portion of the compression gas from the cylinder, is utilised to atomise or vaporise more effectively the liquid fuel. According to the invention, vaporisers for internal-combustion engines comprise a casing or carburettor body *a* provided with a receptacle *l* to receive the liquid fuel, the top of the receptacle



being formed as a nozzle and provided with a number of layers of fine-mesh gauze *m*. Liquid fuel is admitted to the receptacle *l*, through a float-controlled valve located in a chamber *h* capable of adjustment relatively to the receptacle. The body *a* of the vaporiser is provided with an annular space *c*. A conduit *e* is provided to admit exhaust gases from the engine to the space *c*, an outlet (not shown) also being provided. The receptacle *l* is connected by a pipe *n* with the conduit *e*. To prevent the liquid in the receptacle *l* entering the pipe *n*, the pressure medium from the pipe *n* is caused to traverse the bent tubes *o* which rise above the maximum level of the liquid in the receptacle and are then bent downwards so that the pressure medium is discharged below the liquid. In practice, the liquid fuel is led *via* the flexible pipe *k* to the receptacle *l*, and the height of the fluid in the receptacle is regulated by adjusting the height of the float chamber *h* relatively thereto. The liquid is forced out of the receptacle by the exhaust gases or other pressure medium entering *via* the pipe *n*. (*Accepted November* 29, 1922.)

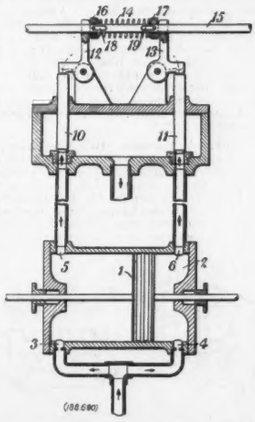
188,727. W. Merrix, Lozells, Birmingham, and H. Clarke, Lozells, Birmingham. Carburettors. (3 *Figs.*) March 3, 1922.—The invention refers more particularly to that type of carburettor wherein the body is of substantially T shape, having a jet or fuel inlet in the vertical leg of the T, one side of the horizontal part serving as an inlet for air and the other side being connected to the induction pipe of the engine. According to the invention, in a carburettor of the type referred to a rotary



sleeve *a*, having ports *l*, contains a barrel *b*, a pin or projection *c* on the sleeve *a* engaging a recess *g* in the periphery of the barrel, and a pin or projection *d* on the barrel *b* passing through an opening *e* in the sleeve *a* and engaging with a recess *f* in the casing of the carburettor. With this arrangement as the ports *l* in the sleeve gradually open the passage for the flow of air past the fuel inlet *k*, so the barrel *b* moves away from the fuel inlet *k*, thus increasing the cross-sectional area of the passage past the fuel inlet. (*Accepted November* 29, 1922.)

HYDRAULIC MACHINERY.

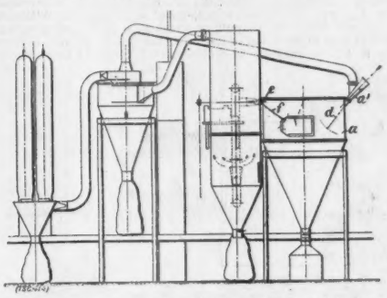
188,680. Gilbert Gilkes and Co., Limited, Kendal, and G. E. T. Thorpe, Kendal. Servo-Motors. (1 *Fig.*) May 12, 1921.—The invention relates to servo-motors of the type in which an element is displaced by means of hydraulic pressure operating on a piston in a cylinder. According to the invention, each side of the piston is subject to a constant pressure of fluid from inlet passages, whilst the position of the piston is controlled by opening one exhaust passage only at a time. The servo-motor consists of a piston 1 contained in a cylinder 2. The inlet pipe is kept constantly supplied with fluid under pressure, which fluid may pass into the cylinder through inlet openings 3, 4. The fluid is discharged through the exhaust passages 5, 6, the discharge being controlled by poppet valves 10, 11 seating on the end of the exhaust passages 5, 6. Fluid pressure in the cylinder is constantly tending to force the valves from their seatings, but is restrained from doing so by cranked tappet levers 12, 13, which normally keep both valves on their



seats by means of a compression spring 14, which spring is constantly exerting a pressure upon loose collars 16, 17 sliding on a rod 15, but having their motion limited by pins and slots 18, 19. The position of the slots 18, 19 is such that when the rod 15 is moved longitudinally (say to the left) the end of the slot 19 engages with its pin and compresses the spring 14, thus exerting a greater pressure on the lever 12 to hold the valve 10 on its seating and reducing the pressure on the lever 13. This allows the valve 11 to be forced from its seating by the fluid pressure in the cylinder, thus forming a communication from the cylinder through the passage 6 to exhaust and reducing the pressure at that end of the cylinder; the pressure at the other end being in excess, the piston is moved to the right and will continue to move until the rod 15 is brought back to a central position, when the piston will remain stationary. If the rod 15 is moved in the opposite direction the above-described motion will be reversed. (*Accepted November* 29, 1922.)

MINING, METALLURGY AND METAL WORKING.

188,414. W. Yates, Swinton, Manchester, and Matthews and Yates, Limited, Swinton, Manchester. Grading Ores and Coal. (4 *Figs.*) August 18, 1921.—The invention relates to means for grading crushed ores, coal and the like, of the type wherein the grading is effected by introducing material along with a current of air which, in passing through the apparatus, cause the material to separate and deposit at different positions according to the weight of the individual particles. In accordance with the invention, hinged plates *d*, *f* are provided beneath both the inlet and outlet ports a^1, *e*, respectively, situated at the upper end of a hopper or receptacle *a* into which the material to be



graded is fed, the plate *d* beneath the inlet port a^1 determining the angle at which the material is projected towards the side of the hopper containing the outlet port *e*, and the gap or distance between the adjacent edges of the plates determining the grade of material which is drawn through the outlet port *e* with the air current. (*Sealed.*)

188,814. J. S. Atkinson, Westminster, and The Powdered Fuel Plant Company, Limited, Westminster. Magnetic Separators. (2 *Figs.*) August 25, 1921.—The invention has reference to magnetic separators in connection with the treatment of coal which is to be burnt in a pulverised condition. A magnetic separator, in accordance with the invention, comprises

Fig. 1.

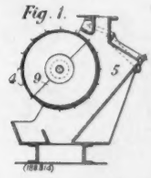
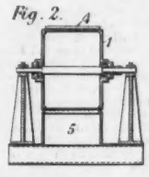


Fig. 2.

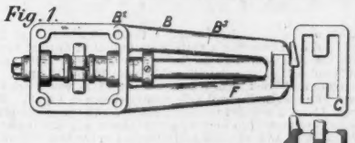


a horizontally-mounted and rotatable hollow drum 1, a stationary magnet or magnets 9 within the drum, vanes 4 projecting from the exterior of the drum parallel with its axis, and a vertical or approximately vertical duct 5, the walls of which partly enclose the drum, so that the passage of material along the duct acts on the vanes and sets the drum in rotation. (*Sealed.*)

MOTOR ROAD VEHICLES.

188,444. A. Alderson, Stoke, Coventry. Change-Speed Gearing. (3 *Figs.*) September 12, 1921.—The invention relates to change-speed gearing for use on motor vehicles of the kind in which the gear lever, the "gate," the gear-lever shaft, and the operating and locking mechanism are combined upon a bracket to constitute a separate unit adapted to be mounted upon the upper part of the gear-box and arranged to close an aperture therein, into which parts of the aforesaid mechanism project. The gear-box (part of which only is shown at A) is formed with a rectangular aperture A^2 in its top, which receives a bracket B that comprises a rectangular frame B^2 and a skeleton arm B^3. The arm B^3 carries the quadrant C and the pivot pin D for the change-speed lever E. Within the rectangular

Fig. 1.



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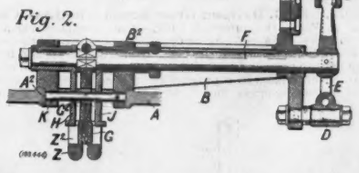


frame B^2 the sliding rod F has attached to it the selector arm G which projects into the gear-box and is adapted to engage the jaws Z^2 on the selector rods Z. The rod F has freely mounted upon it a pair of interlocking fingers H, J adapted also to engage the jaws Z^2 in the selector rods and to move sideways with the sliding rod and selector arm, but not to twist therewith. To prevent this twisting, the interlocking fingers H, J on the side of the shaft F nearest their acting ends are threaded upon a pin K fixed in lugs depending from the bracket B to form a locating spigot connection with the gear-box, and to allow the arm G to twist a curved slot G^2 is formed in it through which the pin K passes freely. The edges of the aperture in the gear-box serve to locate the pin K endwise without necessitating a head and nut upon it. (*Sealed.*)

188,360. J. H. Chandler, London. Draught Gear and Buffer Mechanism. (3 *Figs.*) July 6, 1921.—The invention relates to a draught gear mechanism for road vehicles adapted also for use as buffer mechanism. The invention consists in a duplex draught gear and buffer device, one of which is located at each side of the road vehicle and comprises spaced bearings A, A^1, each containing a hollow shaft B, B^1, which slides in its respective bearing and is provided at its inner end between the bearings with a collar or abutment C, C^1, which may be in the form of a nut. Other collars, abutments or stop nuts D, D^1, are provided on the outer ends of the hollow shafts B, B^1.

Within the hollow shafts slides the rod E and coiled about that part of the rod which lies between the bearings A, A^1, is a strong helical spring H which bears at its opposite ends against the abutments C, C^1 of the hollow shafts B, B^1. The rod E is also provided at one end with a nut F, which bears against the abutment D^1 of the hollow shaft B^1, and at the opposite end with a head G which bears against the abutment D of the hollow shaft B and may form the forward pulley end of the device. With such a construction when the pull or shock is in a forward direction, that is in the direction of arrow *x*, the nut F on rod E bears against the collar D^1 of the hollow shaft B^1, which latter slides in

Fig. 1.

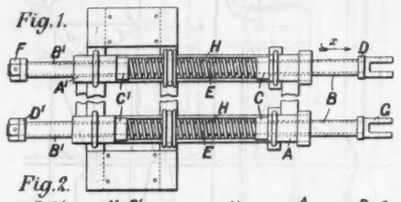
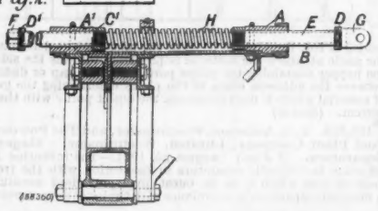


Fig. 2.



the bearing A^1, and the collar C^1 at the opposite end of said hollow shaft acts on the spring H to compress same; on the other hand when the pulling strain or shock is in the reverse direction, the head G on rod E bears against the collar D of hollow shaft B which latter slides in the bearing A and the collar C at the opposite end of this hollow shaft B acts on the spring H to compress it. Whatever the direction of shock or pull, the spring is always under compression, and by the location of the spring between the two collars C, C^1, rebound action of the spring on release of the strain or shock is reduced to a minimum. The head G may be replaced by another nut as F or other suitable element according to the use of the device. (*Sealed.*)

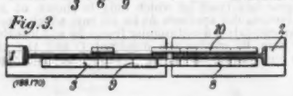
RAILWAYS AND TRAMWAYS.

188,170. Francis Theakston, Limited, Westminster, London, and F. Theakston, Westminster, London. Joining Railway Rails. (6 *Figs.*) October 12, 1921.—The invention relates to improved means for joining the ends of rails. According to the invention, there is secured near to one end of each rail a plate having a downward-projecting hook which is preferably bolted to the rail web and is adapted to be engaged by an upturned hook on a plate on the end of an adjoining rail. 1 and 2 are rails. To the rail 1 a reversible plate 3, having downward-projecting hooks 4, 5, is secured by a bolt passing through a hole 6 in the plate 3 and rail 1. It will be observed that the

Fig. 1.

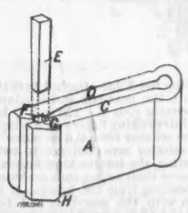
Fig. 2

Fig. 3.



hook 4 is nearer to the hole 6 than is the hook 5. The rail 2 has secured to it on one side a plate 8 having an upturned hook 9, and on the other side a guide plate 10 by means of bolts passing through holes 11 in the plate 8, guide plate 10 and the rail. The guide plate and hook form between them a fork which embraces the web of an adjoining rail as is clearly shown in Fig. 3. When the rails 1 and 2 are laid in a straight line the reversible plate 3 is secured to the rail 1 in such a position that the hook 4 is engaged by the hook 9, and when it is desired to move the rails out of alignment and form a curve the plate 3 is reversed so that the hook 5 is engaged by the hook 9. (*Sealed.*)

188,014. R. G. Davison, Great Sutton. Railway Chair Keys. (1 *Fig.*) December 20, 1921.—The invention relates to metal chair keys of a self-locking type. The key is constructed in the form of a U spring A, the outer arm C of the spring being bevelled at the open end so facilitate insertion in the metal chair. The bevel terminates in a projection or knee H and causes the key to become securely locked as soon as it is driven home.



Inside the two arms C, D, and near the open end of the key, vertical guides or slots are provided to receive a steel wedge E which, when driven down the guides or slots, produces a lateral expansion of the key. The guide or slot on the inner arm D is designed to clear the bull head of the rail. This arm is serrated on the face which bears against the flange of rail for the purpose of minimising creep. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

189,202. A. Welin, London. Hoisting and Lowering Boats. (2 *Figs.*) August 22, 1921.—The invention relates to hoisting apparatus especially applicable for hoisting in and lowering boats on board ship. In hoisting apparatus constructed according to the invention, the hoisting drum is loosely mounted on an axle A, which is carried in eccentric blocks B. The axle A is provided with a crank D having mounted upon it a rotating spindle E on which is fixed a pinion F meshing with a

Fig. 1.

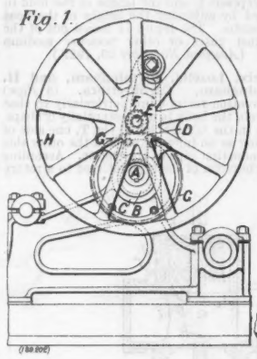
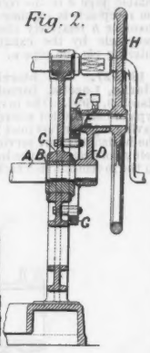


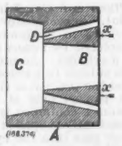
Fig. 2.



fixed ring or arc of teeth G; the spindle is also provided with a handle wheel H for rotating it. It will be seen that when the hand wheel is turned in the one direction or the other, the axle A is so moved relatively to the bearings C that the drum can be put into engagement either with driving collars or with a brake. (*Accepted December* 6, 1922.)

STEAM ENGINES, BOILERS, EVAPORATORS, &c.

188,374. L. Grote, Tottenham. Liquid Hydrocarbon Burners. (2 *Figs.*) August 4, 1921.—The invention refers to an auxiliary combustion chamber and means for highly heating air for use in conjunction with liquid hydrocarbon burners. A flame port or passage B is provided centrally through a body A made of heat-resisting material in the form of a block. The inner side of the block A is provided with a deep circular recess C of much greater diameter than the flame port or passage B and extending inwards for about a third of the thickness of the block A. The chamber C is concentric with the flame or passage port B, which latter is advantageously formed tapering. Surrounding the flame port or passage B is a series of air ports or passages D extending from the front outer face of the block A through the latter



into the chamber C; these air ports or passages D are advantageously each of conical or gradually widening or tapering form, and each is advantageously arranged at an angle to the longitudinal axis of the flame port or passage B so that the streams of air as they emerge from the ports or passages D impinge on the flame as it emerges from the port or passage B into the chamber C. The operation is as follows: A liquid hydrocarbon burner is placed in position to direct the flame axially through the flame port or passage B; the injection action causes air to be drawn through the air ports or passages D and to converge on and mingle with the flame just as the flame enters the chamber C. The block A is mounted in the wall of the furnace, and becoming very highly heated thereby heats the air as it passes through the air ports or passages D, and also forms a highly heated auxiliary combustion zone in the chamber C. (*Accepted November* 22, 1922.)

188,090. F. Durrant, London. Belt Fasteners. (13 *Figs.*) May 11, 1922.—The invention has reference to belt fasteners of the type comprising a pair of doubled or folded plates hinged together and having rows of prongs punched up therefrom, the prongs being intended to be driven through the belt and clinched over. The belt fastener consists of two halves hinged together by a pin *a*. Each half comprises a double plate formed by bending a plate back upon itself and constituting an outer plate *b* and an inner

Fig. 1.

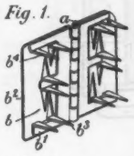


Fig. 2.

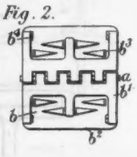


Fig. 3.

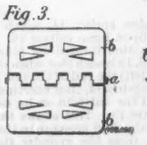


Fig. 4.

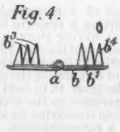
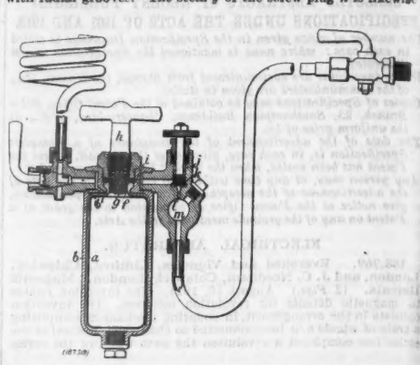


plate b^1, the bends of the two halves being gapped so as to fit into one another and looped so as to receive the hinge-pin *a*. The free ends of the outer plates are bent slightly inwards, as illustrated at b^2, and the inner plates are substantially of E form. The outer plates have V-shaped spikes b^3 punched inwards therefrom so as to stand at right angles thereto. The inner plate b^1 is also provided with spikes b^4, these spikes being formed by pointing the extremities of the outer limbs and turning them up at right angles thereto. (*Sealed.*)

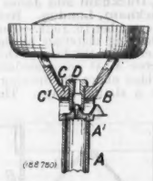
[1] **187,519. Sir J. Dewrance, Southwark, and E. W. Johnston, Honor Oak. Sight Feed Lubricators.** (1 *Fig.*) December 23, 1921.—The invention relates to displacement lubricators of the sight-feed class, and specially adapted for use where the lubricating agent consists of colloidal graphite in a state of suspension in water. Aqueously borne lubricant is confined in a collapsible bag *a* enclosed within a container *b*, to which, by the inlet b^1, water under pressure is admitted. The neck of the bag *a* is secured in the neck of the container *b* by means of a flanged nipple *f*, the face of the flange being formed with radial grooves. The stem *g* of the screw-plug *h* is likewise



formed with longitudinal grooves, thereby enabling the lubricant fluid to pass from the interior of the bag *a*, by way of the longitudinal grooves in the stem *g*, and the radial grooves in the face of the nipple *f*, to the passage *i*, and thence to the chamber *j*, wherein is mounted the regulating valve *k*. This valve controls a passage *l* leading to the sight-feed chamber *m*. (*Sealed.*)

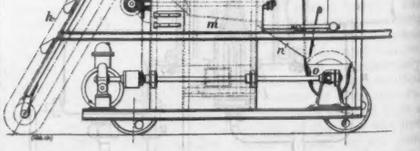
MISCELLANEOUS.

188,780. A. Kitson, Stamford. Burners for Liquid Fuel. (5 *Figs.*) August 17, 1921.—The invention relates to burners for liquid fuel of the Swedish type in which the vapouriser is carried above the nipple. According to the invention, there is provided a burner for liquid fuel comprising a seating A^1 at the end of the fuel conduit A, upon which a nipple can be clamped, a sleeve nut D or the like carried by a fixed part of the burner concentrically with the nipple and capable of being screwed towards the seating, and a stamped sheet-metal nipple B clamped on the seating by the sleeve nut D. According to one feature of the invention as applied to the Swedish type of burner, wherein a part of the vapouriser C is carried in advance of the nipple



and is provided with a lateral opening C^1 giving access to the nipple, the sleeve nut D is carried by the vapouriser, and the proportions of the vapouriser and lateral opening C^1 therein are such relatively to the nipple that the latter can be introduced through the lateral opening on to its seating or removed therefrom without completely withdrawing the sleeve nut. According to another feature of the invention, a stamped sheet metal nipple is made attached to a series of such nipples all made integral from a single piece of metal. Such a series of nipples is particularly suitable for use with the Swedish type of burners, since the nipples of the series which are not in use project out from the lateral opening C^1 and serve as a handle when changing the nipples. (*Accepted November* 29, 1922.)

189,181. S. S. Gettings, Dorking, Surrey, and W. L. Bodman, Dorking, Surrey. Making Tar Macadam (4 *Figs.*) April 1, 1922.—The invention relates to the production of tar macadam. According to the invention, the stone is gradually heated without violent agitation, delivered to a drying device wherein it is slowly turned over to expose it to hot gas for the evaporation of traces of moisture, and discharged into a measuring apparatus, and the tar is simultaneously heated and measured off in corresponding quantity, the measured quantities of the two materials being then mixed or combined substantially without fall of temperature. The improved machine for carrying out the process comprises a continuous slow-running



elevator *h* of bucket type discharging the crude stone at the head of the machine. A receiving hopper *l* is provided to feed the stone on to a slow-movement conveyor *l* with shallow buckets upon which the stone is gradually heated during its travel, this heating device being located throughout its length in the combustion chamber *g* of a furnace. A drying drum *m* is also arranged in which the heated stone can evaporate any traces of moisture, the products of combustion from the furnace being drawn or forced through and around the drum. The measuring device is shown at *n*, and may be a hopper, into which the dried stone is delivered, while a mixing apparatus *o* is furnished into which the heated stone is tipped, and wherein the charge of stone is mixed with a measured quantity of heated tar. (*Accepted December* 6, 1922.)